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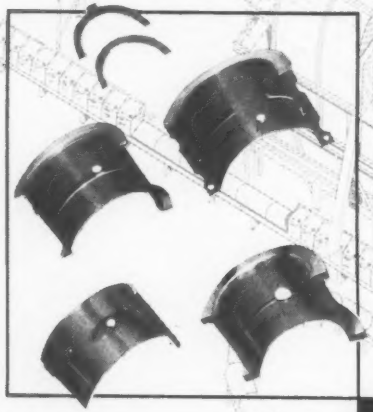

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Citizens of Tomorrow*

A report on this important subject has been published by King George's Jubilee Trust. The book is the result of Working Parties each dealing with one of four phases: (1) full-time attendance at school; (2) after leaving school—influences of employment; (3) the same period, but considering the influences of leisure time; and (4) National Service. It is the second part which is of major interest to readers, as it is the only section with which they are closely associated. Moreover, this Working Party had a distinctly foundry flavour, for it was presided over by Sir Harold West and had the support of Mr. W. B. Beard and at least three other members with foundry interests.

The recommendations of the Working Parties are, *force majeure*, an aggregation of pious hopes, but certainly command the earnest attention of the educational authorities. The suggestion is made that the entry into industry should receive more-enlightened attention from school teachers and that appropriate works visits should be undertaken. A personal view is that these are infinitely more realistic, even if less cultural, than visits to the opera, museums, and the like. Moreover, properly staged, they can be made just as interesting. Reading between the lines, it would appear that the Youth Employment Service needs improvement. There is one badly-phrased injunction "that the responsibility for watching over the industrial life of every juvenile rests primarily on the employer" We would have preferred the phrase "beneficially guiding" instead of "watching over," as the latter merely means making a mental record of the boy's progress. A new note was struck in recommending earlier promotion of girls to positions of increased responsibility, as nowadays there is a marked tendency for the lasses to continue in their jobs after marriage.

The other sections of the report, especially that covering National Service, should be read by all executives. Authoritative information as to the major objectives of military, air-force, and naval training has seldom been expressed so clearly. The perusal of this section gives the opportunity to the executive intelligently to discuss with the called-up apprentice every aspect of his period with the Forces. It is a matter of some interest that this report is not merely of use to the larger establishments, but is of urgent interest to every person who must, or should, give thought to the citizens of to-morrow. This is emphasized by the statement that: The sound upbringing of young people depends, neither on the State and its instruments, nor on voluntary organizations and institutions, but on the adults who are in contact or concerned with young people in their daily lives.

* Published by Odhams Press Limited; price 3*s*.

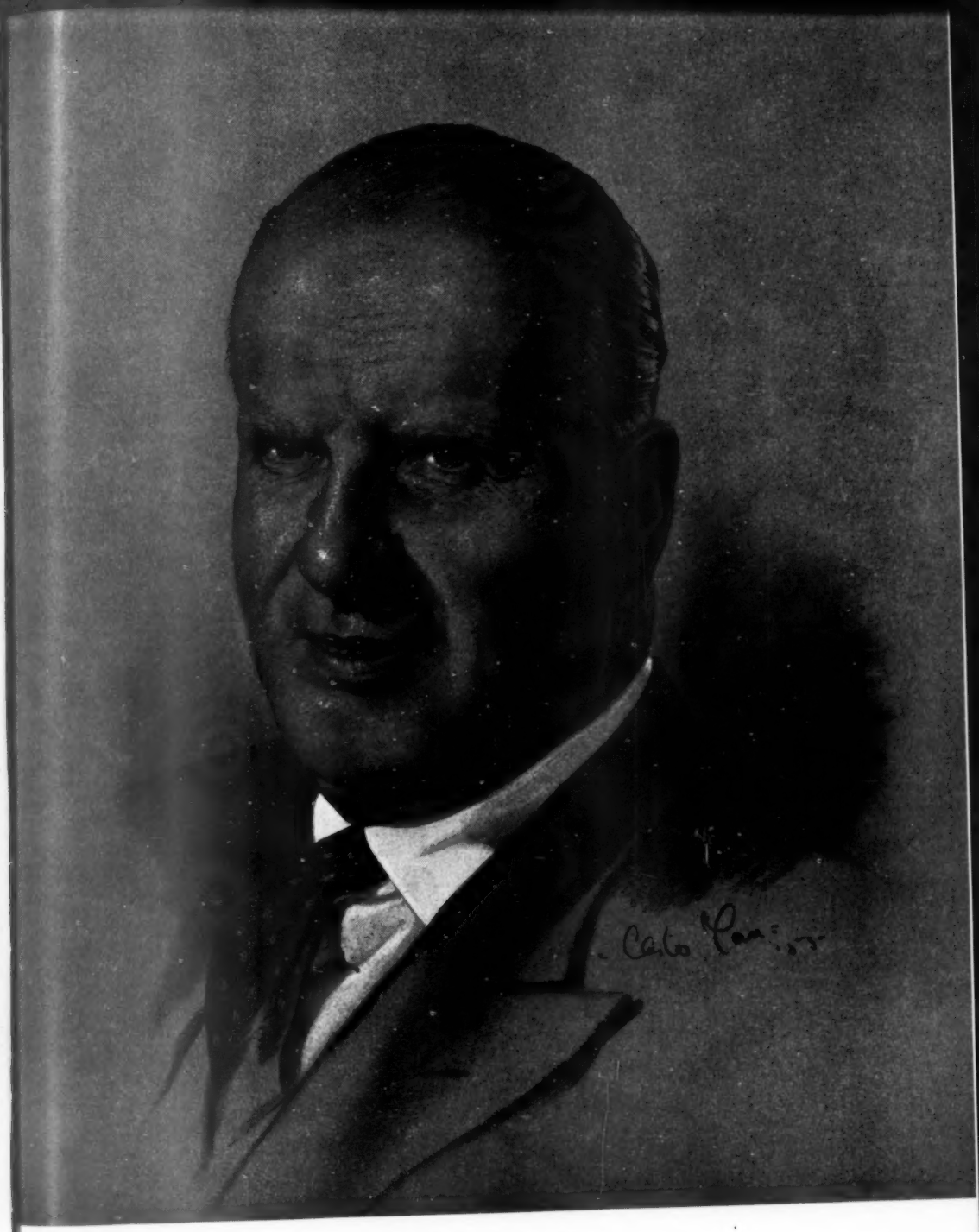
Leaders of the Industry

LOUIS FLETCHER

MR. LOUIS FLETCHER, the vice-chairman of the Light Metal Founders' Association, is a leading personality in the light-alloy industry, having been associated with the aluminium casting side for 36 years. He started his connection with this industry at the early age of 14, when he got his first job as junior draughtsman with the Birmingham Aluminium Castings Company, Limited. His apprenticeship completed as a die designer, he joined F. H. Adams, Limited—later taken over by Northern Aluminium Company, Limited —where he has been for the last 30 years, the past 17 years as manager of the Birmingham works. Being what is now termed by that rather uncouth expression "association-minded," he was a founder member of the Light Metal Founders' Association in 1939. His main interest being technical development, he soon became chairman of the Associations' technical committee, a position he has held for the last ten years. In addition, he has been vice-chairman of the Association for the last year. He is also an active member of the Aluminium Development Association, where not only castings, but also forgings, come within his purview.

Most people have outstanding interests amongst their business activities, and that of Mr. Fletcher is the recruitment and training of entrants to the foundry industry, not only as regards young craftsmen but also training for managerial positions. He has given practical effect to this endeavour by being a Governor of the National Foundry College since its inception in 1947. He is an ardent advocate of the need for better-housekeeping in the foundry industry. Only by better attention being paid to problems of radiant heat from furnaces, regular and constant air changes, full use of mechanical aids and adequate ablution facilities, will the industry attract and retain a steady supply of the right kind of labour.

Mr. Fletcher keeps abreast with current technical developments by periodic visits to the Continent and North America. For relaxation he is an enthusiastic golfer and takes an active interest in both local and national politics.



LOUIS FLETCHER

Vice-chairman, Light Metal Founders' Association

Congress Paper Authors

Mr. Edgar Bull Simonsen, a member of the *Norsk Metallurgisk Selskap,* is joint author with Mr. Floyd Brown of the official Norwegian Exchange Paper—"Widmanstätten and Other Abnormal Forms in Cast Iron," printed on page 499 of this issue. Born at Trondhjem, Norway, in 1923, Mr. Simonsen received his general education in Norway, Italy and Germany. From 1943 to 1951 he studied inorganic chemistry at the University of Oslo and obtained the degree of Mag. Scient. for a thesis on grain boundary cementite in mild steel. After graduation he took up his present position at the Central Institute for Industrial Research. In 1953, under the auspices of the Royal Norwegian Council for Scientific and Industrial Research, Mr. Simonsen came to England where he worked on high-temperature at the Department of Metallurgy at Cambridge University.

E. B. SIMONSEN

Mr. Floyd Brown studied at the Carnegie Institute of Technology, where he gained the degree of D.Sc., in 1950. Prior to this he was associated with the Metals Research Laboratory, Carnegie Institute of Technology, and since graduating has held research posts at the Massachusetts Institute of Technology and the North Carolina State College. Dr. Brown, who holds an appointment at the Naval Research Laboratory, Washington, was associated with the Institute for Industrial Research, Oslo, during the summer of last year.

Dinners

JOINT IRON COUNCIL

The annual banquet of the Joint Iron Council was held on Tuesday at the Dorchester Hotel. The president, Mr. N. P. Newman, J.P., was in the chair. The chief guest was the Rt. Hon. Peter Thorneycroft, M.P., President of the Board of Trade. At the high table were:—Sir Hugh Beaver, M.INST.C.E., M.I.CHEM.E.; Mr. George Beharrell; Mr. H. C. Bradbrook; Mr. F. Bray, C.B.; the Rt. Hon. the Viscount Bruce of Melbourne, C.H., M.C., F.R.S.; Sir Roger Duncalfe; Sir Lincoln Evans, K.B.E.; Dr. A. B. Everest, PH.D., F.I.M.; Sir A. William Grant, C.B.E.; Mr. Chester M. Gray; Sir John Green; Brig.-General Sir Harold Hartley, K.C.V.O., C.B.E., M.C., F.R.S.; Mr. Barrington Hooper, C.B.E.; Sir Hubert Houldsworth, Q.C.; Lieut.-Colonel H. H. Jackson, O.B.E., M.C., T.D., D.L.; Mr. V. Jobson; Mr. G. H. Johnson, M.I.MECH.E., F.I.M.; Mr. Aubrey Jones, M.P.; Mr. Francis D. Ley, T.D., J.P.; the Rt. Hon. A. R. W. Low, C.B.E., D.S.O., T.D., M.P.; Sir Andrew McCance, F.R.S., D.SC., LL.D.; Mr. S. W. Martin; Sir Andrew Naesmith, K.B.E.; Prof. Sir Eric Rideal, M.B.E., F.R.S., D.SC., F.R.I.C.; Mr. L. H. Robinson, C.B.; Mr. Francis Rogers; Mr. S. H. Russell; Sir Frederick Scopes; Mr. James Shaw; Sir Robert Shone, C.B.E.; Mr. D. O. Sillars; Sir Rowland Smith, M.I.MECH.E., F.R.S.A.; Mr. Sydney Smith; Mr. J. F. Stanier; the Rt. Hon. Peter Thorneycroft, M.P.; Major-General Ll. Wansbrough-Jones, C.B., C.B.E.; Mr. Harold A. Watkinson, M.P.; Sir Harold West, and Mr. FitzHerbert Wright.

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Engineer/Foundryman Co-operation

London IBF Members hear of French Progress

For its October meeting, the London branch of the Institute of British Foundrymen took the most unusual course of specially inviting lecturers from France. They were Mr. G. Blanc (director of research) and Mr. M. Jaumain, both of the *Centre Technique des Industries de la Fonderie,* and their subject—"Co-operation between Engineer and Founder on Casting Design." This subject has often been postulated as an outstanding necessity in the foundry industry to-day and the French have probably made more progress than any other foundry group in this sphere. Welcomed to the meeting by the branch president, Mr. F. Hudson, F.I.M., in addition to local members, were members of the Institute's sub-committee, T.S.50 on design, the membership of the National Society of Master Patternmakers, and the Institute's National secretary, Mr. G. Lambert. The sub-committee representatives were headed by their chairman, Mr. J. Blakiston, M.I.Mech.E. (junior vice-president of the Institute), and the Society by its president, Mr. B. Levy, and secretary, Mr. G. B. Judd.

Mr. Blanc acted as spokesman and the lecture opened with an historical account of published information on design recommendations. This was followed by a detailed review of the *Centre Technique's* books on steel- and iron-castings design, respectively ("*Guide Pratique du Trace des Pieces en Acier Moule,*" and "*Guide Pratique de Trace des Pieces Moulees en Fonte Grise*"). The lecturer drew attention to a number of examples where co-operation with designers had proved most advantageous, and illustrated these with slides. At the conclusion of Mr. Blanc's address, Mr. V. C. Faulkner read a translation of a contribution from Mr. Jaumain. One of the most interesting aspects disclosed was the fact that some French engineering concerns are now submitting new designs for castings first to the *Centre Technique* for "vetting" before placing orders with individual foundries. A suggestion was made that the *Guides* might well be translated into English, as it was thought that they would provide a basis for co-operation with designers until the Institute's own recommendations, following on the work of its sub-committee, were published. A very lively discussion on a wide basis followed the presentation of the Paper and a vote of thanks to the lecturers was warmly accorded on a proposal of Mr. Faulkner, seconded by Mr. R. W. Ruddle. The London branch was congratulated on its enterprise in bringing an "international" flavour to its monthly meeting.

Latest Foundry Statistics

According to the Ministry of Supply, the output of aluminium castings during August was 1,495 tons from sand moulds; 3,555 tons as gravity-die, and 1,252 tons as pressure-die castings. The production of magnesium castings was 338 tons.

As reported by the British Iron and Steel Federation's monthly *Bulletin* for September, there was a reduction of 266 workpeople engaged in the steelfoundry industry between July 9 and August 6. The figure at the latter date was 19,633 and the reduction might be due to annual holidays. The weekly average output of steel castings during July was 4,700 tons, being well below the average for the first seven months which was 5,800 tons.

Widmanstätten and other Abnormal Graphite Forms in Cast Iron*

By E. Bull Simonsen, Mag. Scient.,† and Floyd Brown, D.Sc.‡

The appearance and condition of formation of a number of abnormal graphite forms in grey cast iron, associated with impaired mechanical properties, are described. A rationale of these several forms is proposed. First, earlier references in foundry literature to Widmanstätten-type graphite are quoted. Then, the Authors' investigations on castings of 1 to 6 tons are reported, though no correlation between metal composition and the occurrence of abnormal graphite was observed. It is postulated that the formation of Widmanstätten-type graphite is not a function of a critical cooling-rate or is it reproducible after heat-treatment.

Investigation of trace elements present along with the abnormal graphite forms led to the suspicion that lead and tin might be causatory features, and experiments proved that in fact Widmanstätten-type graphite was associated with a lead addition to a melt, tin giving a negative result. Other experimental work is proceeding, but interim conjectures are made as to the possible mechanism of formation of the abnormal structures.

Introduction

That two grey irons of the same nominal flake type and the same matrix may have substantially different properties is well recognized, and indeed the practice of inoculation is aimed in part at altering somewhat the graphite contour while keeping it still flake; new methods of improving this contour while retaining the basic flake have been a by-product of the development of nodular iron. The studies here reported were done on the principle that one way of improving the normal is to study the inferior.

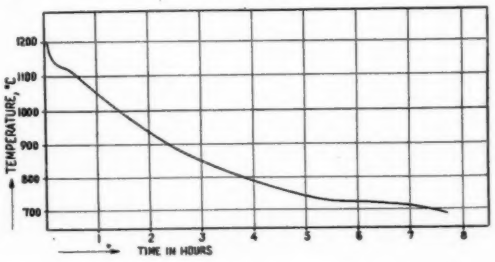
Earlier Literature

Widmanstätten graphite, perhaps the most detrimental of these structures, appears to have been described in the following papers: Corson[1] showed a well-developed Widmanstätten graphite structure in an iron containing about 15 per cent. Si and 0.25 per cent. C. Hanemann and Schrader[2] illustrated Widmanstätten graphite in engineering castings containing 2.62 per cent. C; 2.63 per cent. Si; 1.09 per cent. Mn; 0.075 per cent. S; and 0.30 per cent. P; but gave no details of melting practice or section size. Piwowarsky, in reproducing these photomicrographs, expresses his doubt as to whether they really represent segregate graphite. Morrogh[3] and Morrogh and Williams[4] have illustrated how Widmanstätten graphite can be formed in irons of high sulphur and low manganese content, in the first of the papers for example in a mottled iron containing 2.55 per cent. C; 2.71 per cent. Si; 0.13 per cent. Mn; 0.156 per cent. S and 0.136 per cent. Zr. Since the reversible reaction $Mn + FeS \rightleftharpoons MnS + Fe$ tends to proceed to the right at low temperatures, by adjusting the sulphur and manganese contents the iron can be made to solidify white and graphitize after solidification. The Authors thus suggest that eutectic carbide may decompose in the solid state to give Widmanstätten graphite.

Materials Investigated

Each of the anomalous forms reported here have been observed many times. The iron, made from various proportions of pig and scrap, was melted in an acid-lined Héroult furnace of 7 tons capacity, tapped at 1,500 deg. C., inoculated with cold pig-iron, CaSi, or FeSi, and poured at 1,350 deg. C. The castings weighed from 1 to 6 tons, and section size varied from 1 to 5 in. They were moulded in dry sand. A typical cooling curve of the sinkhead of a 4-ton casting is reproduced in Fig. 1. The typical composition of the metal used was 3.0 to 3.3 per cent. C; 1.0 to 1.6 per cent Si; 0.8 per cent.

FIG. 1.—*Cooling curve for the sinkhead of a 4-ton casting.*



* Exchange Paper from the *Norges Stoperitekniske Forening* (Norwegian Foundrymen's Association) presented at the fifty-second annual meeting of the Institute of British Foundrymen and International Foundry Congress in London, last June.

† Central Institute for Industrial Research, Oslo, Norway.

‡ Naval Research Laboratory, Washington. Formerly temporarily associated with the Central Institute for Industrial Research, Oslo, Norway.

FIG. 2.—*Bayonet-shaped graphite "growing" through a phosphide - eutectic area; etched 4 per cent. picric acid in alcohol.* × 600.

Mn; about 0.2 per cent. P; and less than 0.08 per cent. S.

Many of the heats, of composition within the above ranges, do not show the anomalous forms described later, and when they do appear, not all of them may necessarily appear in the same specimen. There was essentially no correlation between composition within the ranges shown and the incidence of these forms.

The mechanical properties of the specimen may decrease from 200 to below 150 BHN and from 35.0 to below 10.0 tons per sq. in. transverse strength (1 by 1 by 5-cm. span) where the anomalous condition is acute.

Eutectic-derived Structures

Bayonet-shaped primary flake-graphite (Fig. 2) is so straight that it resembles somewhat small kish flakes. These bayonet flakes, generally in ASTM type "A" distribution, are often seen terminating in massive carbides which themselves may be associated with phosphide-eutectic areas, or they may even be growing right through this last-solidifying liquid.

Frequently the bayonet graphite is branched until it can be described as claw-like or chelate (Fig. 3). The flakes may show enclosures of metal, as also illustrated in Fig. 2. These enclosures might be explained as resulting from two branches of a claw growing together again.

Often the bayonet (as well as the more-nearly-normal) graphite terminates in an exceedingly thin graphite tail or web (Fig. 4) which itself has been seen to merge into a thin film of carbide. In some cases the graphite webs are very extensive, and may completely envelop whole grains (Fig. 5). The hexagonal axis of the graphite of these films (as determined by polarized light) is normal to the trace of the film. Clearly enough, such graphite films must be detrimental to transverse strength.

Pro-eutectoid Graphite (Segregate or Secondary Graphite)

As eutectic austenite cools, the carbon rejected along the A graphite line (E'S') normally deposits as a smooth layer on the primary graphite flakes. Often, however, this pro-eutectoid graphite attaches to the primary flake as small hairs, or bristles which at low magnifications gives the flake a "fluffy" appearance. Morrogh[5] points out that this secondary graphite at high magnifications may be found to be arranged in a Widmanstätten formation, in rare cases in a well-arranged pattern.

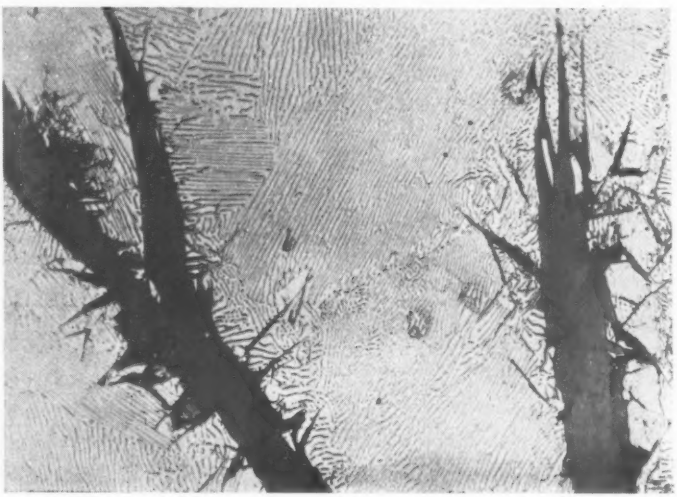


FIG. 3.—*Claw-like graphite flakes, covered with needles of secondary graphite; etched 4 per cent. acid in alcohol.* × 600.

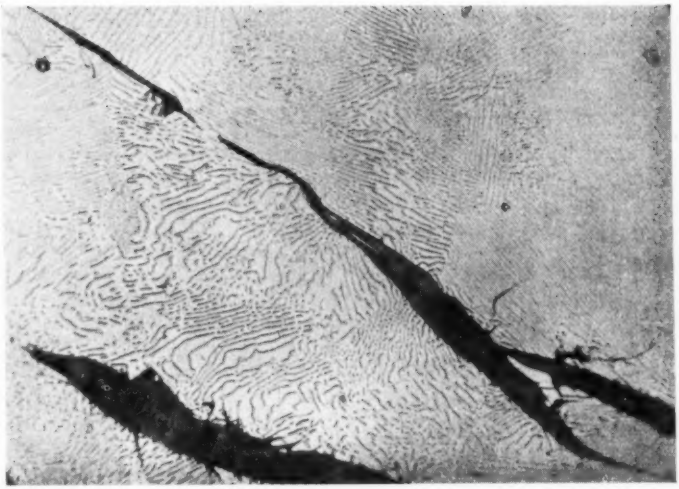


FIG. 4.—*Thin graphite tail, also showing small enclosures of metal; etched 4 per cent. picric acid in alcohol.* × 600.

In more acute cases of this form of precipitation, the Widmanstätten pattern reaches a high degree of perfection. Examination under polarized light demonstrates that the plates are graphite, and again with the hexagonal axis normal to the trace of the plate. Fig. 6 shows the general appearance of the structure at low magnification, and Figs. 7 and 8 represent two frequently-observed forms at higher magnification, both from the same specimen. The appearance of Fig. 6 suggests that with inferior specimen preparation or cursory examination, Widmanstätten graphite might escape detection and the structure may well occur more often than the rare mention in the literature would indicate. From the four trace directions of the triangular Widmanstätten graphite plates indicated in Fig. 7, one would be tempted to infer that the habit plane is the (111) of the austenite. But bearing in mind the very small thickness of the plates it seems to be evident from Fig. 8 that the graphite lies on planes of higher indices—they could perhaps be the same as for Widmanstätten carbide plates.

When the specimen is cut approximately parallel to one of these planes, it is possible by careful polishing to retain some of the graphite plates, which then are polished parallel to the basal plane, and maintain the same degree of blackness during rotation under polarized light. Where these graphite plates are polished away, the underlying ferrite is revealed and suggests that the Widmanstätten graphite is occurring in a wholly ferritic matrix. Sometimes this is true, but usually the matrix is pearlitic, and the ferrite lying under these plates extends only a short distance below the graphite plate before giving way to pearlite.

The Widmanstätten graphite is usually found around the ends of primary graphite flakes, and the patches sometimes seen apparently isolated in the matrix probably appear isolated because the observation is made on a two-dimensional plane only. The Widmanstätten graphite patches also appear to be associated with the late-freezing ternary phosphide areas (Steadite).

The specimens are often slightly mottled, and besides primary graphite and ternary phosphide the Widmanstätten graphite may be associated also with massive cementite, though there are also examples where there is found no cementite at all. This mottling tendency is thought to be due at least partly to a residual chromium content of (normally) from 0.2 to 0.3 per cent. which may be much more highly concentrated in the last solidifying eutectic liquid. The fact that the massive cementite particles are only slightly coloured by alkaline sodium picrate (light

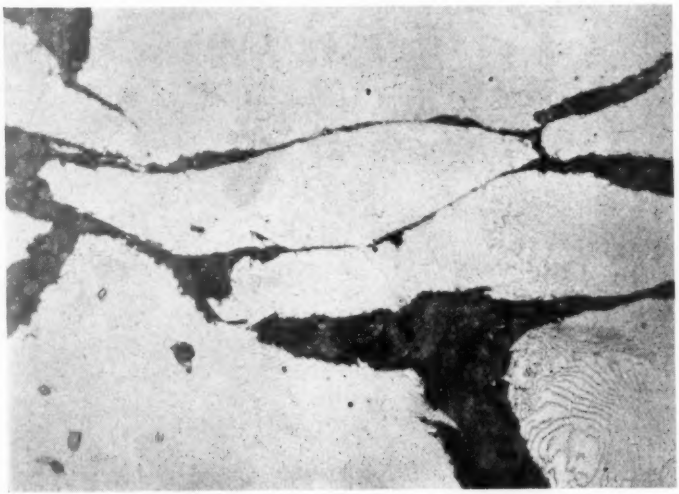


FIG. 5.—*Graphite web enveloping a grain; etched 4 per cent picric acid in alcohol.* × 600.

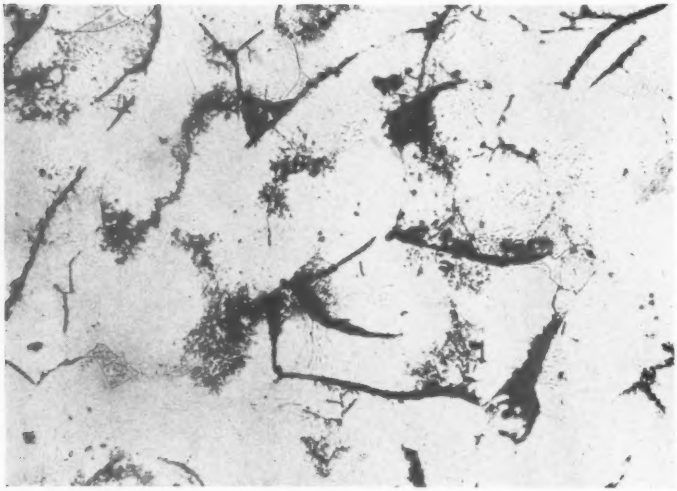


FIG. 6.—*General appearance at low magnification of a specimen having large amounts of Widmanstätten graphite; etched 4 per cent. picric acid in alcohol.* × 150.

yellowish-brown to green colour) and often have the shape of a heavy, straight-sided bar seems to substantiate this explanation. (Compare[2], Figs. 127-129.)

Widmanstätten Carbide

Occasionally, but very rarely, Widmanstätten carbide plates were also found, a rare phenomenon in cast irons. Fig. 9 illustrates an area with Widmanstätten graphite and Widmanstätten carbide etched with 4 per cent. picric acid in alcohol, and Fig. 10 shows the same area after additional etching in cold alkaline sodium picrate to darken the cementite.

From the general behaviour of carbides during graphitization it is considered unlikely that Widmanstätten graphite derives from Widmanstätten carbide: there does not seem to be any evidence in the literature of graphite ever taking the morphology of the carbide from which it is derived.

A series of cooling-rate experiments indicate that the appearance of Widmanstätten graphite is not a very sensitive function of cooling rate. Also the large variation in weight and section size of the actual castings indicates that the cooling rate is not very critical, as long as the cooling is comparatively slow.

A large number of small specimens from castings containing Widmanstätten graphite was heat-treated to dissolve the Widmanstätten graphite and cooled at many different rates. The dissolved carbon always was redeposited in a more normal manner, and it was not found possible to reproduce by such heat treatment the Widmanstätten structure.

In specimens removed from the furnace during heating up (especially in the range from 850 to 930 deg.) there had formed a lot of small grains or droplets in the matrix round the steadite and comentite areas (Fig. 11). According to Hanemann[2] (page 61 and Fig. 359) this is phosphide which is rejected from the matrix having a high phosphorus content near the Steadite. These droplets were *also* found round the areas with Widmanstätten graphite, but *not* near the flake graphite. Most of these droplets were too small to permit identification by etching with Murakami reagent, but the largest droplets were coloured just like the phosphide in the Steadite.

Chemistry

The statement that composition variables could not be correlated with tendency toward the appear-

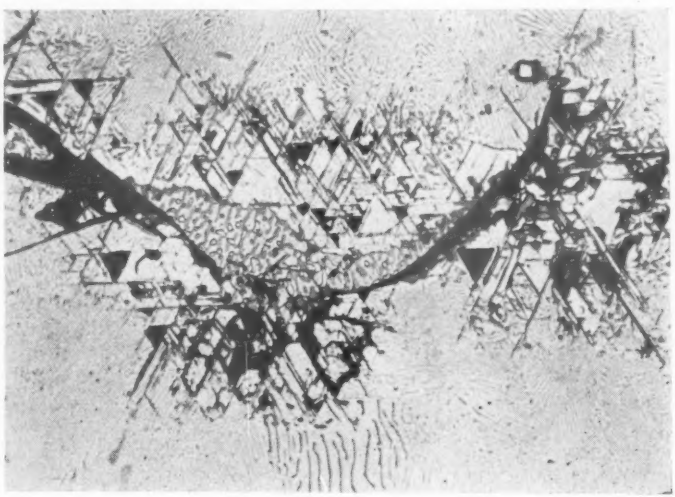


FIG. 7.—*Widmanstätten graphite showing triangular graphite plates and, in the centre, a Steadite area. Etched with 4 per cent. picric acid in alcohol plus an aqueous solution of alkaline sodium picrate to darken the cementite.* × 600.

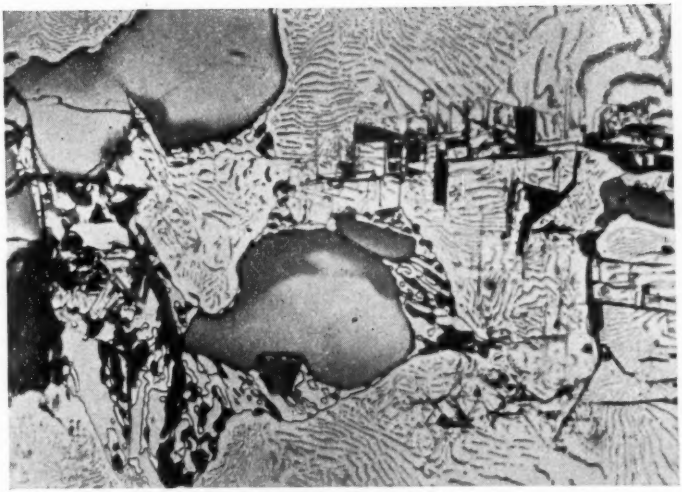


FIG. 8.—*Widmanstätten graphite showing nearly rectangular graphite plates. To the left are two large carbide grains, which are only slightly coloured, and Steadite; etched as Fig. 7 (same specimen).* × 600.

ance of one or more of the anomalous graphite forms has to be modified slightly, as it applies only to the five mentioned elements. Through the kind co-operation of Mr. Morrogh the British Cast Iron Research Association furnished more than 30 spectographic analyses of specimens of varying soundness. The metallic residuals average 0.15 per cent. Ni; 0.21 per cent. Cr; 0.09 per cent. Cu; 0.055 per cent. Ti; 0.1 per cent. V; 0.017 per cent. Sn; 0.0097 per cent. Pb; 0.029 per cent. As; and approximately 0.029 per cent. Sb. Mo was below 0.02 per cent., Al below 0.01 per cent., and Bi, Te and B were not detected.

Plotting the content against hardness or transverse strength indicated no marked correlation for most of the residual elements, but Pb and Sn seem to impose a strength limitation. The content of Pb varied from less than 0.003 to 0.03 per cent. and the Sn content from " not detected " to 0.2 per cent.

To test the suspected effect of Pb, there was made a ladle addition of 1¾ oz. Pb to 220 lb. (50 gm. per 100 kg.) of a split heat, which produced Widmanstätten graphite in test castings, whilst the untreated fraction, poured in castings which solidified at the same rate, were sound, and both harder and stronger. As it is difficult to raise the lead content of cast iron, upon addition, the Pb content only increased from 0.004 to 0.016 per cent., less than one-third of the added amount. Repeated experiments showed up to 30 per cent. reduction in transverse strength.

Similar experiments with the addition of 1¾ oz. Sn to 220 lb. of molten iron—resulting in an increase from 0.005 to 0.02 per cent. Sn—have so far failed to show anomalous structures or reduced strength. Because high values for the Sn content seem to be followed by high values for Pb in the spectrographic analyses referred to, the strength limitation apparently imposed by Sn thus may be coincidental. Further experiments to identify other elements capable of acting similar to Pb are under way. (It must be emphasized again that the irons are electrically melted at high temperatures. Cupola-melted irons perhaps will not react the same way.)

Many if not all of these graphite forms appear in the areas which are late to freeze (witness the frequent association with the late-freezing Steadite) which means that in this slow solidification unfavourable residuals can be concentrated to a degree not possible in smaller castings, as has already been suggested for chromium. It may well be that some of the

FIG. 9.—*Claw-like graphite flake and Widmanstätten graphite (left), and Widmanstätten carbide (right). Several TiC particles; etched 4 per cent. picric acid in alcohol.* × 600.

FIG. 10.—*Same area as Fig. 9, but additionally etched in an aqueous solution of alkaline sodium picrate to darken the Widmanstätten carbide (right).* × 600.

seemingly insignificant trace elements are thus concentrated to the degree required to cause these abnormal morphologies, and that for this reason attempts at correlation of the occurrence of these structures with gross chemical analysis have been fruitless.

Conclusions

It is tempting to conjecture that these anomalous forms reflect graphite/metal interfacial energies altered (as such energies can easily be) by the presence of small amounts of impurities. This idea is being explored experimentally. It seems to be a useful working hypothesis that there is a continuous gradiation from one extreme—the Widmanstätten graphite—*via* blunter and blunter flakes to the other extreme—graphite spherulites. Variations in interfacial energies are thought to be the factor governing these morphologies, and minor elements—also gases—again to be responsible for the variations of the interfacial energies. In this connection it is extremely interesting to note that small amounts of residual elements like Pb, Bi, Sb, Ti and others[6] may prevent the formation of nodules when Mg is added.

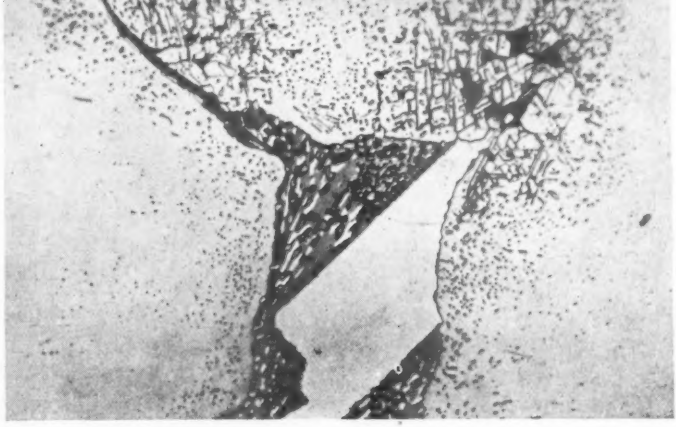


FIG. 11.—*Small droplets appearing near areas having Steadite or Widmanstätten graphite after heating to 850 deg. C. and quenching. Etched with 4 per cent. picric acid in alcohol (hardly any effect) and additionally with Murakami's reagent.* × 600.

This working hypothesis is supported by the recent contribution of Grütter and Marinček[7 8] who show that when S is added to a synthetic cast-iron, the surface tension is progressively reduced, and at the same time the graphite morphology goes through the sequence from spherulitic to flake graphite.

ADDENDA

It had already been stated that there could be found no correlation between gross chemical analysis and the tendency towards the appearance of the one or more of the anomalous graphite forms. This was not so with respect to the residual elements. Through the very kind co-operation of Mr. Morrogh, the British Cast Iron Research Association had furnished nearly 40 spectrographic analyses. These had led to the construction of new diagrams, Fig. A, concerning the graphite of specimens containing, respectively, arsenic, antimony, tin and lead.

In the first diagram, Fig. A (*a*), transverse strength was plotted against per cent. arsenic. The filled-in circles represented sound castings, and the Ws represented castings containing more or less Widmanstätten graphite. Arsenic seemed to have no adverse effect on traverse strength or on the frequency of appearance of the Widmanstätten graphite. The same applied to the next diagram,

where the antimony present showed at least no clear-cut correlation.

The diagram for tin was not so easy to interpret. All the castings with a high tin-content were unsound; but so were many of those with a low tin-content, indicating that tin alone could not be responsible for the defects. The last diagram, Fig. A (*d*), demonstrated the effect of lead, and here there was a clear correlation. In fact, the Authors had been able to confirm this finding repeatedly by adding small amounts of lead to split heats otherwise giving sound castings, although it was difficult to get sufficient lead dissolved in the iron. The point to the upper right of Fig. A (*d*) representing a "sound" casting in spite of the high lead-content must be considered as an "outsider." That particular casting had a low carbon and silicon content which resulted in large amounts of cementite, and for that reason showed a high transverse strength.

Acknowledgments

The Authors wish to thank Mr. Alf Sanengen, the director of the Central Institute for Industrial Research, Oslo, for permission to publish this Paper.

REFERENCES.

[1] M. G. Corson, Am. Inst. Min. & Met. Eng., 1928, Techn. Publ. No. 96.
[2] Hanemann and Schrader, *Atlas Metallographicus*, II Figs. 154-156 (Gebrüder Borntraeger, Berlin 1936).
[3] H. Morrogh, *J.*, Iron & Steel Inst., 1941, 195-205 (Figs. 22-24) and 207-252 (Fig. 73).
[4] H. Morrogh and W. J. Williams, *J.*, Iron & Steel Inst., 1947, 321-371 (Figs. 71 and 72).
[5] H. Morrogh, *Metallurgia*, 1941, 151-154.
[6] H. Morrogh, B.C.I.R.A., *J.* of Research and Development, 1952 **4**, (No. 5), 292-314, and *Trans.*, A.F.S., 1952, **60**, 439-452.
[7] K. Grütter and B. Marinček, *Giesserei*, Technisch-Wissenshaftliche Beihefte, 1953, No. 12, 587-592.
[8] K. Grütter and B. Marinček, *Arch. Eisenhütten w.*, 1954, **25** (No. 9/10), 447-453.

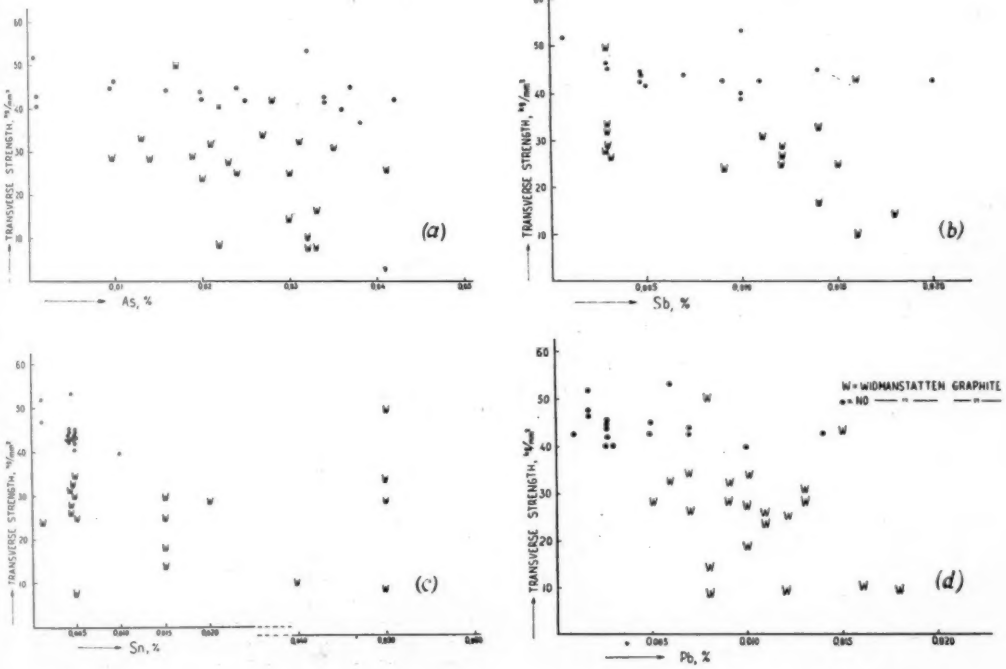
DISCUSSION

Author's Introductory Remarks

Introducing the joint Paper by himself and Dr. Brown at the Congress, MR. E. BULL SIMONSEN (from Norway) said that a very efficient way to improve the mechanical properties of cast iron was by altering the graphite contour and ultimately to produce nodular iron. The main intention of the present contribution was to present some abnormal graphite structures that seemed to represent the other extreme, both regarding mechanical properties and graphite contour. There were very few references to such structures in the literature.

The Authors had found the anomalous graphite

FIG. A.—*Occurrence of Widmanstätten graphite and its effect on transverse strength of irons to which (a) arsenic; (b) antimony; (c) tin and (d) lead has been added in increasing quantity*



forms in iron from the regular production of a foundry producing heavy castings. The iron was melted electrically in a 7-ton Héroult furnace, and there was nothing special about the chemical composition. Normally, the iron was of a very high quality, but whenever one or several of the abnormal structures were observed, there was a marked decrease in transverse strength, and mostly also in hardness.

Commencing with the primary flake graphite, this might become very straight and pointed and look like what has been termed "bayonet" flakes. They were often seen growing right through a phosphide area, and very often the ends of the flakes were split up into several branches. Further, the pointed ends may terminate in an exceedingly thin tail, which had been seen to merge into a film of carbide. These films might be very extensive, and envelope a whole grain.

The hexagonal axis of the photomicrograph was normal to the trace of the film and clearly enough such films were detrimental to transverse strength.

The carbon which was rejected during cooling of the saturated austenite normally was deposited on the primary flakes as a smooth layer. It might also be deposited as small hairs or bristles, giving the flakes a "fluffy" appearance. Morrogh had pointed out that this secondary graphite at high magnification could be seen to be arranged in a Widmanstätten formation. In acute cases, the Widmanstätten pattern reached a high degree of perfection. [Mr. Simonsen then showed slides of typical structures, taken from the Paper, at increasing magnifications.]

From the four trace directions of the triangular Widmanstätten graphite plates shown in the last slide, he said one would be tempted to infer that the habit plane was the (111) of the austenite. However, the more-or-less rectangular form seen in the earlier slide seemed to indicate that the graphite lay on planes of higher indices. The hexagonal axis again was normal to the trace of the plane.

Widmanstätten graphite areas were usually found around the ends of the primary graphite, and also seemed frequently to be associated with the late-freezing phosphide areas. Very rarely, the Authors had also found castings containing Widmanstätten carbide, the same castings also containing varying amounts of Widmanstätten graphite. As graphite never seemed to take the morphology of the carbide from which it was derived, it was considered unlikely that Widmanstätten graphite was formed from Widmanstätten carbide, but admittedly the two formations looked very similar.

Extent of Occurrence

MR. H. MORROGH, opening the discussion, said that the Authors had done a great service in drawing the attention of foundrymen to the problem of Widmanstätten graphite in grey cast iron. Graphite in this form might account for more failures than was at present suspected, although the inference which might be formed from the Paper was that these graphite structures were somewhat rare. It was of course true that Widmanstätten graphite structures so well developed as those shown by the Authors were only heard of on rare occasions, but it had been his observation, and Mr. Simonsen had commented on it, that the secondary graphite —that was, the hyper-eutectoid and eutectoid graphite of ordinary cast irons—was very frequently found to be arranged in a Widmanstätten pattern in heavy castings, if the specimens were carefully examined at a sufficiently high magnification. It seemed that this Widmanstätten form of graphite could appear in scarcely perceptible amounts quite frequently, but the well-developed structure occurred somewhat infrequently.

In considering this subject, it was useful to bear in mind the conditions under which Widmanstätten structures occurred in general. When one had a solid solution capable of depositing a second phase over a range of temperature, there was always a chance that the second phase would be arranged in a Widmanstätten pattern, subject to the appropriate crystallography of the depositing and the parent phase. Since hyper-eutectoid graphite formed over a range of temperature by deposition from austenite it was perhaps not altogether unexpected that such graphite might on occasions be found in the Widmanstätten form. The surprising thing, therefore, was not that it occurred at all, but that it did not appear more frequently in a well-developed form.

Possible Origins

In most alloys, the normal Widmanstätten structures were formed by the deposition of a phase from a solid solution which existed in the form of polyhedral grains. In such alloys, conditions favouring the formation of a Widmanstätten structure were coarse grain-size, accompanied by a critical cooling rate. The normal mode of deposition of the second phase was at the grain boundaries, but with a coarse grain-size and with insufficient time for diffusion to the grain boundaries, the second phase was deposited in a Widmanstätten pattern.

In cast iron, the hyper-eutectoid graphite was not normally deposited at the grain boundaries of the austenite, but on the pre-existing eutectic graphite flakes instead, so by analogy one would expect Widmanstätten structures to occur most readily in samples having relatively large graphite flakes in irons of relatively low total carbon contents and where one had considerable diffusion distances between the individual graphite flakes.

On the other hand, quite apart from this elementary possible mechanism for the formation of Widmanstätten graphite structures, many alternative explanations were possible. For instance, hyper-eutectoid cementite could be readily obtained in a Widmanstätten pattern in white cast iron. It could also be obtained in grey cast irons of very-low-silicon and also high-sulphur contents. Most of the irons referred to by Mr. Simonsen were low-silicon cast irons and in such irons one might obtain the hyper-eutectoid constituent as cementite fairly readily and this cementite might graphitize *in situ*.

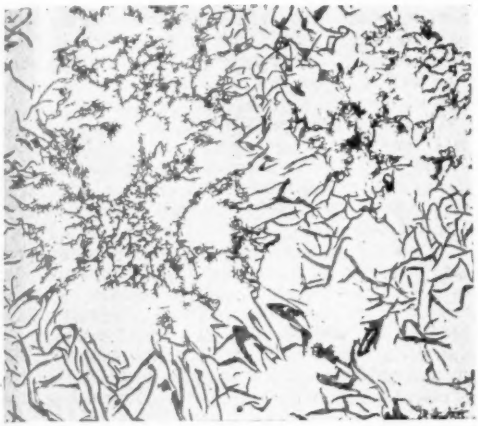


FIG. B.—*Fine and normal flake forms of graphite in iron treated with bismuth;* × 100; *etched in picral.*

It was submitted that this mechanism was not entirely unfeasible.

He would also, however, like to draw attention to the fact that in cast irons one occasionally obtained Widmanstätten graphite structures which seemed to correspond to the eutectic graphite and not to the hyper-eutectoid phase. Many years ago, Corson showed, for high-silicon cast irons, that all the eutectic graphite could be obtained in a Widmanstätten pattern and he had been able to confirm that. If eutectic graphite was incapable of existing in a Widmanstätten pattern, it would mean either that a Widmanstätten pattern could form directly from the liquid, which he submitted was extremely improbable, or that the structure arose as the result of the decomposition, for instance, of iron carbide shortly after solidification, and in this connection it was interesting to note that Morrogh (*JISI*, No. 1, **41**, 195-205 and 207-286) and Morrogh and Williams (*JISI*, March, 1947, 321-371) had produced eutectic graphite in a Widmanstätten pattern in irons containing relatively high sulphur contents. There was some circumstantial evidence to indicate that, in irons of high sulphur content, the eutectic solidified as ledeburite and that graphitization occurred subsequently.

In any case, he was convinced that no simple logical explanation could at this stage be entirely satisfactory to explain the occurrence of Widmanstätten graphite in grey cast irons.

Elements Favouring the Occurrence

Mr. Simonsen had been able to show that the occurrence of the structure was facilitated by contamination of the melt with lead. In partial confirmation of this finding of Mr. Simonsen, he (Mr. Morrogh) could show that Widmanstätten structures could be deliberately produced by the addition of bismuth to grey cast iron in amounts of the order of 0.001 to 0.05 per cent.

Fig. B showed the general graphite structure of such a bismuth-treated grey cast iron at a fairly low magnification. Around the periphery of this, one could see normal flake-graphite and also some more-finely-divided graphite. At a high magnification, this finely divided graphite frequently had a mesh pattern as shown in Fig. C. Mesh graphite of this type probably arose from the decomposition of ledeburite after solidification (Morrogh, *JISI*, No. 2, **46**, 399-414). In some areas of the fine graphite in such a sample, one obtained a Widmanstätten-like deposition of graphite associated with the mesh graphite, as shown in Fig. D. In addition to this, additions of bismuth readily produced well-formed Widmanstätten patterns of graphite

FIG. C.—*Mesh graphite in bismuth—containing cast iron; etched in picral;* × 600.

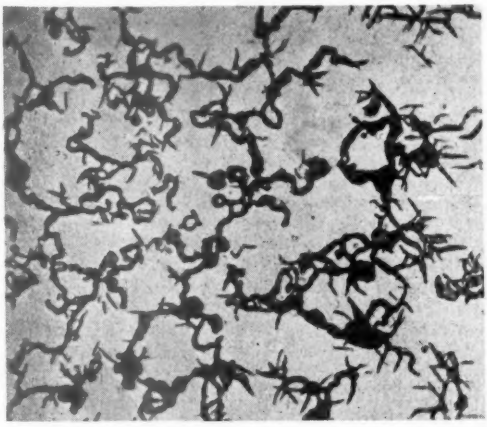
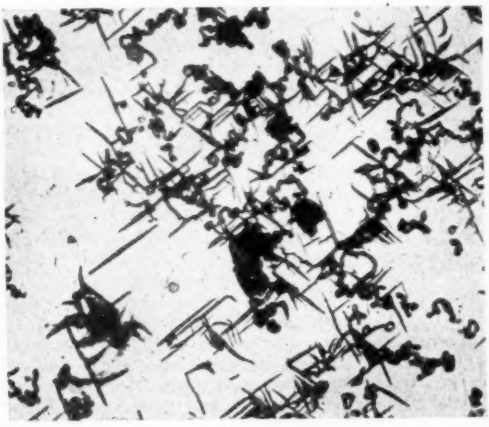


FIG. D. — *"Widmanstätten-like" deposition of graphite associated with mesh graphite in bismuth—containing iron; etched in picral;* × 600.



Widmanstätten Graphite—Discussion

adhering to normal eutectic flake-graphite, as shown in Fig. E. The structures shown in these illustrations were obtained in a test-bar 3 in. dia. cast in a green-sand mould from metal treated with a small amount of bismuth; the effect of bismuth was quite reproducible. In view of the chemical similarity of lead and bismuth it was perhaps not surprising that a similar effect in this connection might be attributed to lead as well as bismuth.

He had found that additions of bismuth caused the formation of the Widmanstätten structures to occur over a fairly wide range of section size and it therefore seemed that bismuth rendered the critical cooling rate less important. He had never been able to produce Widmanstätten graphite structures deliberately by lead additions. On the other hand, from time to time he had had an opportunity of examining material submitted by various people, having Widmanstätten structures and he had not yet been able to explain the fortuitous occurrence of the structure in such samples in terms of the bismuth content.

FIG. E.—*Secondary graphite in Widmanstätten form attached to a eutectic flake in a bismuth-containing iron; etched in picral;* × 1,500.

Complicating Phenomena

MR. SIMONSEN, replying, said their work represented just a start on the problem, which was certainly very complicated. The metal referred to in the Paper was melted electrically and very large castings were made from it. It contained, according to the analysis of a number of castings, a number of elements, such as titanium, vanadium, arsenic, and antimony. He did not think that the cooling rate was really so very critical in that case.

The castings examined weighed from one to seven tons. Lately he had made a survey of the occurrence of the defect and it turned out that always when there was a defect in one casting from a melt, all the castings from that melt were defective. So it would appear that the composition was very significant. In the last case which he had seen, there were two castings from the same melt, one weighed a ton and the other six tons, and they both had the same defects; both had cooled very slowly. What was to be done next was to try and make smaller test-castings and see at what point the Widmanstätten structure might disappear.

He was very pleased to hear that Mr. Morrogh had been able to get the same structure as had been illustrated, and to produce it at will by adding bismuth. That Mr. Morrogh had not been able to get it by the addition of lead might, he thought, be due to the fact that Morrogh's iron must have been much more pure than that which he, Mr. Simonsen, had been using. That was taken from the regular production in the foundry and contained many contaminating elements.

A MEMBER asked where the specimens were taken from the casting and what was the cooling rate.

MR. SIMONSEN said the specimens were taken by drilling from the sink heads or, if the casting was to be rejected, at different depths below the surface of the casting itself.

The cooling curve for a four-ton casting was illustrated in Fig. 1. About this, he would say that at one time they were pouring separate bars of a diameter of two to three inches and that the defective structure very rarely appeared, and there were only a few traces of Widmanstätten graphite. However, the castings themselves could be so "rotten" that one could pull out grains with one's finger nails. A bar two or three inches in diameter seemed to cool too quickly to give that sort of structure.

MR. MORROGH explained that experiments to which he had referred dealt with irons containing bismuth and the structures were obtained in test-bars of from one to three inches in diameter, cast in green-sand moulds.

Effect of Copper

DR. R. V. RILEY said that the Widmanstätten type of graphite was of great interest and that this Paper and others published recently had helped founders to understand the reasons for the many types of graphite observable in the microstructure of cast iron.

Some years ago he had observed Widmanstätten graphite in the microstructure of iron containing 10 to 15 per cent. of silicon (Fig F*). The change to the Widmanstätten type of graphite in the high-silicon iron appeared, in his experiments, to be brought about by additions of copper. The amount of Widmanstätten graphite present in the microstructure increased with the amount of copper added, until, at about 5 per cent. of copper, all the graphite was in that form.

He would suggest to the Authors that copper was an element which might be added to the list of

* From "Microstructure of Commercial Acid-resisting Silicon/Iron Alloys" by J. E. Hurst and R. V. Riley. *J I. & S. Inst.*, Feb. 1947, p. 172.

residual elements given in their concluding paragraph, namely Pb., Bi, Sb and Ti; and it was noteworthy that copper was also a subservient element in respect of nodular-iron production.

MR. SIMONSEN was interested to hear that copper had that effect because since the Paper had been written he had been adding many different metals to the melt. He had noted from the paper by Morrogh the detrimental effect of certain trace elements in nodular iron. He had added both lead and copper and got horrible structures, very weak in transverse strength and the whole casting contained Widmanstätten-type graphite. To the next day's melt he had added copper alone and the result was quite normal! At present, he had the feeling that the copper increased the action of the elements which might cause the defective structure. Although a diagram correlating transverse strength with antimony-content did not show any marked decrease of strength—he had been adding antimony in the ratio of 1:1,000 to the cast-iron melts and such metal had also shown a low transverse strength, but he had not examined all the structures yet. It had given a not quite typical Widmanstätten graphite, but a very unsound structure.

A MEMBER referred to Fig. 3 in the Paper and said when founders got that type of structure they generally considered that there was also a layer of secondary graphite on both sides of the flake, underneath the crystals but also at the edge and side of the flake. Had Mr. Simonsen noticed something like that? Also, it had been observed that the direction of crystal growth did not seem to be in proportion to the direction of the pearlite heart.

MR. SIMONSEN, in reply, said he would expect to see that type of graphite in addition to the existing graphite.

The PREVIOUS SPEAKER added that the flake did not seem to be weak, nor did it seem to be a true graphite. Generally, it was found that the two layers sometimes thickened up both sides of the flake.

MR. SIMONSEN agreed that in such irons, it was very easy to show that they had a layer of secondary graphite, especially under polarized light. He had not paid much attention to looking for both forms, but he would not be surprised to find that both were there.

"Widmanstätten Graphite a Cause or Effect?"

MR. J. E. O. LITTLE pointed out that Mr. Simonsen had referred to defective graphite and had mentioned defective castings. Was he to understand that a number of rejected castings were found to contain that form of graphite, or having rejected castings for some other reason, the particular form of graphite was noted, subsequently? Also, was the defective graphite found in all parts, or did it occur a certain distance in from the surface? When drilling the casting, was there a layer of normal metal before the defective graphite was reached ha'f-an-inch or so below the surface, or something like that?

MR. SIMONSEN replied that in any case castings would be rejected when the defective graphite structure was observed. When much of the particular structure was present, it could be seen during machining, for it gave very short turnings which easily broke up and looked like black dust, but when present in small amounts, the structure could not be detected during machining. Castings with a Widmanstätten graphite structure did not give good wearing properties and would be rejected for that reason.

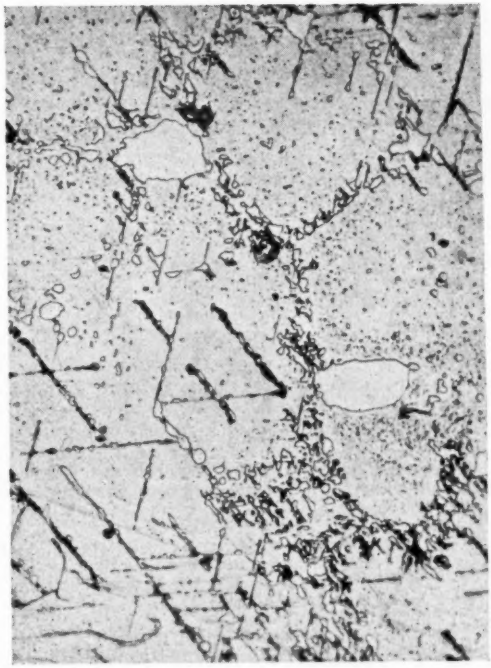


FIG. F.—*Widmanstätten graphite structure in iron containing 15 per cent. Silicon,* × 600.

Note: All the graphite in this specimen was of this form, due apparently to the 5 per cent. addition of copper. Globules of copper may be observed in the Widmanstätten pattern.

Regarding the depth at which the structure occurred, he would say that the deeper one got into the interior of the casting the more would be present and the coarser the grain-size became. As the structure seemed to be very much coupled with late-freezing, it was usually found in the centre of the casting. He could not give any data as to how far one had to go in from the surface to find it, in fact, in many cases it was found also close to the upper surface. In bad cases, it went right through the casting and in slight cases there might be but few traces in the centre only.

At the conclusion of the meeting, the president expressed appreciation of the Author's most interesting Paper, and in proposing the vote of thanks made special reference to Mr. Simonsen being there in person, introducing the Paper and replying so ably to the discussion.

Foundry Trades' Equipment and Supplies Association

Annual Report

At the annual general meeting of the Foundry Trades' Equipment and Supplies Association, held at the Waldorf Hotel, London, on October 27, the following report of the year's activities up to December 31, 1954, was presented:—

Membership

The number of members of the Association at December 31, 1954, was 68. Compared with last year, this number indicates an increase and constitutes an all-time record for membership of the Association.

Accounts

The accounts of the Association for the year ended December 31, 1954, showed a surplus of £139 16s. 8d., making a balance of £206 2s. 0d., to be carried forward.

Council

During the year under review the Council held eight meetings, and numerous matters of interest to members have been published in circulars. Mr. Alfred C. Turner, a founder member of the Association, on his retirement from General Refractories, Limited, did not seek re-election to the Council and Mr. R. H. Mardell, of the same company, was elected by ballot to fill the vacancy. The Council wish to record their appreciation and thanks to Mr. Turner for his services since the formation of the Association in 1925.

Circulars

Details of trade enquiries received by the Association have been circulated to interested members and in addition, circulars have been sent to members at intervals throughout the year giving details of events which have taken place, and commenting on some of the matters which have received the attention of the Council.

Handbook

1,200 copies of the Association's handbook have been distributed to foundries in Holland, Norway, Denmark, Belgium, India, Australia and the Union of South Africa, these being in addition to over 3,000 copies distributed to foundries throughout the United Kingdom. In view of the success of the revised handbook the Council feel that a third edition, possibly in 1957, would prove beneficial and this matter will, therefore, be referred to members at the annual general meeting to ascertain their views.

National Union of Manufacturers

Mr. D. H. Wood has continued to represent the Association on the executive Council of the NUM. By reason of the fact that the Association is in membership of that organization, individual members wishing to join the NUM receive a rebate of 20 per cent. off their annual subscription to the NUM.

Ventilation Committee (Pedestal Grinders)

Under the chairmanship of Mr. G. E. Lunt, the work of this committee has continued in conjunction with the British Steel Castings Research Association. In addition to research on pedestal grinders, investigations have also been carried out relative to dust extraction on swing-frame grinders.

Institute of British Foundrymen

The annual conference of the IBF was held in Glasgow during June, 1954. It has been customary for members to make, through the Association, donations towards the expenses of annual conferences, but on this occasion the Institute's Scottish members were anxious for the conference to have a distinctly Scottish flavour and the whole of the expenses were therefore subscribed from Scotland.

British Standards Institution

Mr. J. G. Lowe has continued to represent the Association on technical committees of the Institution.

Foundry Trades Exhibition

The Association maintained close co-operation with the organizers of the foundry trades exhibition, held at Olympia in the Engineering, Marine & Welding Exhibition during September, 1955.

General

The Council feel confident that members will endorse the view that the Association has once again had an active and successful year during which the strength of the Association has increased and assistance has been given to members wherever possible. In conclusion, the Council wish to record their appreciation and grateful thanks to those who have served on behalf of the Association for the benefit of the industry.

Election of Officers

It was announced that Mr. W. R. Rawlinson, Mr. Frank Webster and Mr. D. H. Wood had been, as a result of a ballot, re-elected members of the Council.

At a Council meeting following the annual general meeting, Mr. C. Orton Foster, British Foundry Units, Limited, was re-elected president, and Mr. G. E. Lunt, Bradley & Foster, Limited, vice-president. It was also announced that Morgan Crucible Company, Limited, and George Tweedy & Company, Limited, had been admitted to membership of the Association.

Foundry Worker's Claim Dismissed

In Paisley Sheriff Court on October 17 and 18, a civil jury was called to decide an action of damages. Although frequent in the Court of Session in Edinburgh, these trials are still rare in the Sheriff Courts, and this is only the second to take place in Paisley in the last 25 years. A jury of four men and three women sat with Sheriff-Substitute J. D. M. Young, Q.C., in an action brought by Robert William Robinson, a foundry labourer, against his employers, Carntyne Steel Castings Company, Limited, of Renfrew. The pursuer averred that in April, 1953, while working shovelling sand in the machine bay in the foundry, he received injuries to his left foot caused by a heavy casting lying on a pile of sand rolling over and pinning him to the floor. He maintained that the accident was caused through dangerous conditions of working and the castings should have been taken away before he was asked to shovel sand. On behalf of the employers, it was said that their method of working was the usual one, that it was Robinson's job to take away the castings, and that the accident was caused through his own carelessness. After a hearing of evidence lasting two days, the jury returned a verdict for Carntyne Steel Castings Company, Limited, finding that there was no negligence on their part.

SIR BERNARD DOCKER told members of the West Midlands branch of the Institute of Export, on October 25, that the steel industry had increased output by five-eighths, while the number of men had increased by only one-eighth. He would like to see the figures for the nationalized industries. Sir Bernard urged members to use every possible means of making their opinion heard.

Influence of Grain Size on the Structure, Pressure-tightness and Tensile Properties of Sand-cast Bronzes and Gunmetals*

Discussion of the Congress Paper by Mr. A. Cibula, M.A., A.I.M.

One of the most stimulating discussions of the International Congress followed the presentation of this Paper and its chief features are recorded in what follows. Salient points dealt with by the Author concerned: Possible alternative interpretations of the results reported; an apparent "stalemate" position; relation of the work to freezing of other alloys, particularly malleable; importance of casting temperature and pressure tightness; porosity distribution; optimum grain size; directional solidification; mass effects and chilling.

THE CHAIRMAN (Mr. J. Bell), opening the session at which Mr. Cibula's Paper was presented, welcomed Mr. Y. R. W. Granström, president of the International Committee of Foundry Technical Associations, to the meeting in his capacity as associate chairman.

The Paper, entitled "Influence of Grain Size on the Structure, Pressure-tightness and Tensile Properties of Sand-cast Bronzes and Gunmetals," was then presented by the Author, who was associated with the British Non-Ferrous Metals Research Association.

MR. K. REINDERS (Netherlands), opening the discussion, asked the Author if, in his experience, it was only the tin percentage which was important or whether the zinc percentage had any bearing on the experiments; in other words, if one brought the zinc percentage of the alloy to a higher level, would one find the same things at a lower tin percentage?

MR. CIBULA, in reply, said if the zinc content were raised, the eutectoid films appeared at somewhat lower tin contents, but the general variation in the form of porosity with macrostructure was observed in all the compositions which had been studied.

DR. V. KONDIC (Birmingham University) said in the first place he wished to compliment Mr. Cibula on his Paper which was what a paper should be at a conference, very interesting and at the same time provocative. No doubt he would not mind if some of the more provocative points were taken up. In his opinion, the most interesting point was the contrast which had been made between the rather unusual behaviour of copper-base alloys and the light alloys in relation to grain refining. In other words, light alloys benefited metallurgically as well as from the foundry point of view by grain refining, and that was no doubt the reason why most light alloys were at present grain-refined. In contrast to this, Mr. Cibula now suggested that at least for one group of copper-base alloys—and a very important group, the bronze family group—it was not a good thing to grain-refine. Why was it then that copper-base alloys responded quite differently from other alloys from the point of view of grain refining? Was the explanation given by the Author a correct one or was it perhaps incomplete? Dr. Kondic said in his view it was only a part answer: if he had interpreted Mr. Cibula correctly, his explanation was that by grain-refining copper-base alloys the process of solidification was altered, and instead of skin formation there was solidification throughout the section, leading to poor feeding and hence the bad properties.

Parallel Work

To indicate that he had not been discussing this Paper on purely theoretical grounds, Dr. Kondic said he had performed some experiments in the same field of work as Mr. Cibula, at the same time testing the fluidity of the alloys in addition to the properties which were enumerated in the Paper. It was well known that if one added to the bronze family group of alloys small amounts of elements like chromium or aluminium the fluidity was reduced, although they were not grain-refined by such additions, and other properties changed in exactly the same way as Mr. Cibula had described. Consequently, Mr. Cibula had not only grain-refined but had grain-refined with those elements which at the same time lowered the casting fluidity of these alloys. The fluidity values of bronzes which he had obtained, Dr. Kondic said, were quite distinctly lowered, as one might expect, by small additions of boron, zirconium, and similar elements. So, not only was the solidification affected by grain-refining but also the inherent fluidity was hampered by the presence of oxide films which were brought about by the additions used by the Author.

Dr. Kondic said a second question which occurred to him on reading the Paper was that of querying what happened with other copper-base alloys. One could not help feeling that it was a somewhat gloomy picture which had been painted by Mr. Cibula from the point of view of grain refining copper-base alloys. In the introduction to his Paper, Mr. Cibula mentioned two important groups of alloys, namely, aluminium-bronzes and beta-brass—both of which were very important in the foundry industry—which benefited, like light alloys, by grain refining, and two references were given to previous work on that subject. Incidentally the Paper on aluminium-bronzes referred

* Paper printed in the JOURNAL, June 30, 1955

Grain Size of Bronzes and Gunmetals—Discussion

to ingots, and therefore was not relevant to sand castings, and the other one on brasses dealt mainly with iron additions up to 3 per cent. and therefore did not fall within the category of grain refining as this was normally understood.

For that reason, Dr. Kondic said he had experimented with grain refining these two important groups of alloys with similar types of additions, mainly with zirconium as this was done by Mr. Cibula, and, true enough, these alloys when cast into sand moulds behaved completely differently from the gunmetal series. In the case of the manganese-bronzes, the ductility was doubled and so was that of the aluminium-bronze when cast into moulds of the same type. Why was that so? Why should manganese-bronze benefit by grain refining whereas gunmetals did not? The answer was that in manganese-bronzes and alumnium-bronzes one had alloys of the short-solidification range and at the same time these alloys already had elements which were oxide-forming: consequently the addition of the grain refining element did not in any way hamper the fluidity of these alloys—in fact, measuring the fluidity before and after grain refining gave the same result, thus showing that it was not affected.

Concluding his remarks, Dr. Kondic said he wished to emphasize these two major points: poor response to grain refining of the bronze group was essentially due not only to the change of solidification mechanism but also to a lower fluidity, and secondly there were at least two important copper-base alloys which in fact benefited by grain refining.

Disappointing Results

MR. CIBULA, in reply, agreed that the effects of grain-refinement were disappointing, particularly as some time had been spent developing grain-refiners suitable for gunmetals in the hope of obtaining the sort of benefits one obtained in light-alloy castings.

He had not observed that any of the grain-refined alloys had too low a fluidity. It might be true that some of the grain-refining additions reduced fluidity, either because they enhanced the formation of oxide films on the liquid metal or because they caused pasty-type solidification, which interfered with the flow of metal, particularly in a fluidity spiral. However, even if reduction in fluidity did adversely affect the feeding properties of the alloy, as suggested by Dr. Kondic, this did not seem to explain the results described in the Paper. For example, the refined castings had been found generally to contain *less* porosity than the corresponding coarse-grain alloys, an effect which could reasonably be ascribed to an improvement in mass-feeding brought about by grain refinement but hardly to a reduction in viscosity.

Mr. Cibula further said he had not suggested in the Paper that grain refining produced bad effects in all copper-base alloys. On the contrary, in the last part of the Paper he had suggested that brasses, in which porosity was largely inter-granular, might benefit from grain refining, but that point had not been pursued in the work.

A MEMBER (from France) asked why it was more difficult to cast gunmetal of composition 88/10/2 than 85/5/5/5 in a green-sand mould: in other words, why was it easier to make 85/5/5/5 pressure-tight? Would the reason why there were so many rejects in the 88/10/2 alloy have anything to do with the eutectoid of which Mr. Cibula had spoken?

MR. CIBULA, in reply, said the difference between the alloys was probably tied up in some way with their constitution—their freezing ranges and the larger proportion of residual liquid in the leaded alloy—but he was afraid he could not be more explicit.

Effect on Freezing Phenomena

MR. H. G. HALL asked what was the general effect of grain refining on the freezing curve of the alloy. What he was trying to do was to see if he could get a clue from Mr. Cibula's Paper to the hot-tearing epidemics which were occasionally experienced in the malleable-iron industry. He would also like to know if, in the density measurements which had been done, it had been found that in producing the columnar and therefore the pressure-tight casting surface, as opposed to the fine-grain casting, there was a perceptible and constant difference in density measurement—if, in fact, the density measurement could be used to differentiate between soundness and super-soundness, so to speak.

MR. CIBULA, in reply, said the fine-grain alloys were all considerably sounder than those of coarse-grain (calculating the porosities from the densities) as might be seen, for example, from the curves in Fig. 3 (b) of the Paper. With regard to hot-tearing, grain refining seemed to eliminate it from the castings which had been used—for example, from the disc casting in which the hot-tears were illustrated in Fig. 12. Hot-tearing occurred when the dendrites interlocked to form a coherent network which then shrank on subsequent cooling. Interlocking was more difficult in the fine-grain alloys, so that the coherent network of dendrites formed at a lower temperature than in the coarse-grain alloys and, therefore, the temperature range over which the network contracted—and during which it might subsequently tear—was shorter. The beneficial effect of grain refinement on hot-tearing was often used in light-alloy die-casting, for example.

Mr. Cibula said he did not know what effect the grain refiners had on the freezing curve except that they certainly eliminated under-cooling before solidification, but the percentage solid which separated at a given temperature was probably not very much influenced by the small additions which were made for the purpose of grain refinement.

MR. HALL asked if it might be that underneath a hot-tear it had possibly been found in the non-ferrous alloys that there was an area of, say, greater soundness? He personally always thought of the hot-tear as giving atmospheric feeding in that area, but it had not been possible to prove it on white iron, and it would be interesting to hear whether

there was any proof of that phenomena with non-ferrous alloys.

MR. CIBULA said that in the particular casting which was illustrated in Fig. 12 the hot-tears were formed by the collapse of the skin into the unsound region underneath. Many hot-tears, however, were due to the restraint offered by the mould to the contraction of the casting and were not caused by shrinkage porosity, *per se*, although they tended to occur in hot spots and might therefore be associated with porosity.

MR. HALL said he personally had found that if he had a hot-tear he got very little reduction of feed metal in the feeder itself, suggesting that the casting was feeding through the torn skin rather than through the feeder. He would like to know whether Mr. Cibula had found that.

MR. CIBULA replied that he had not observed it in his particular work.

Effect of Casting Temperature

DR. E. SCHEUER (International Alloys Limited) asked Mr. Cibula for a comparison between the behaviour of light alloys having a long freezing range and copper-base alloys. About 20 years ago, he had seen graphs showing the properties of test-bars as a function of the casting temperature, and if he remembered correctly, the effect of high casting-temperature on the long freezing-range of the light alloys was favourable, but with the eutectic alloys it was unfavourable. He thought, to a certain extent, that was what was being found with the copper-base alloys.

MR. CIBULA, in reply, said if he might give an example, about five years ago he and Mr. Ruddle had published some work on the aluminium/4.5 per cent. copper alloy in which they had varied casting temperature, and it had been found that the lower the casting temperature the better were the properties of the test-bars and the finer the macrostructure. In other words, in that particular case, the properties benefited from grain refining and therefore deteriorated with rise in casting temperature, unlike the gunmetal castings made in the present work. He had not had any experience of the effect of casting temperature on the eutectic light alloys.

Importance of Pressure Tightness

MR. G. BLANC (*Centre Technique des Industries de la Fonderie*, France) said he wished to congratulate Mr. Cibula on the way he had conducted the investigation and had insisted especially on pressure-tightness, because, generally, that was much more important than tensile strength. It would be interesting to know if the results which had been found would be the same on machined discs. The casting of such discs was a very severe test for pressure-tightness of metal, and he had found from many such tests that the results could be very different according to whether the discs were machined or not. Of course, when one machined them, and took the bosses away, the shrinkage could have a different influence, but the effect of the skin might also be important. Thus, it would be interesting to know if any investigations had been made in to the influence of machining because, of course, many castings, in industry, had to be machined and it was possible that after removal of the skin different results would be obtained.

With regard to pressure tightness of the discs after oxidizing treatment, and also after degassing, it had been found that the scattered porosity was not so dangerous as the local shrinkage, but it seemed that in Mr. Cibula's work the opposite had been found, and it might be interesting to know if, after machining the same result would be obtained.

MR. CIBULA agreed with most of what Mr. Blanc had said. In the castings which had been made during the work reported, all the fine-grained alloys leaked when unmachined, so they had not continued the investigation by machining the discs. This could have made the coarse-grain castings as bad, but it could not have made them worse, than the grain-refined alloys.

With regard to the very different effects of grain refinement and gas introduced from mould reaction, the cause did not seem to be clear. The effect of gas introduced into a columnar structure by mould reaction was presumably not to eliminate the shrinkage pipe and the zone of micro-porosity associated with it, but simply to make it smaller by forming a little centre-line porosity nearer the perimeter of the plate or disc. In contrast with this, grain-refinement eliminated the pipe or centre-line porosity and spread the porosity over the entire section-thickness. Concluding his remarks, Mr. Cibula said he did not consider the effects produced by mould reaction were as marked as the effects produced by changing the macrostructure.

Type and Distribution of Porosity

MR. R. W. RUDDLE (British Non-Ferrous Metals Research Association) thought it might be helpful to elaborate a little on the different types and distributions of porosity. Mr. Blanc was quite right in that Mr. Cibula's findings did appear to be inconsistent with the commonly accepted view that the harmful effect of shrinkage cavities could be largely eradicated by introducing some gas into the metal; the idea behind this view was that the gas dispersed the shrinkage porosity, thus eliminating regions of gross unsoundness. On the other hand, Mr. Cibula had shown that if the shrinkage porosity were dispersed by grain-refining, the pressure-tightness and strength of bronze castings were worse than before. The key to this apparent contradiction lay in the type of dispersed porosity produced. If the porosity were dispersed with the aid of gas introduced into the metal, the porosity usually took the form of small holes distributed at random throughout the casting. However, when dispersion was effected by grain-refining, it was found that the cavities were often not dispersed at random but were arranged in quite definite layers and it appeared that it was this special distribution—layer porosity as it was called—which gave rise to poor tensile properties and failure under pressure test.

Grain Size of Bronzes and Gunmetals—Discussion

Optimum Grain-size

DR. D. V. ATTERTON (Foundry Services Limited) said that Mr. Cibula's investigation had shown that a decrease in grain size resulted in a deterioration of tensile properties and of resistance to leakage; this suggested that an increase in grain size might cause an improvement in these properties and that there might be an optimum grain-size to give maximum physical properties. Had Mr. Cibula investigated this point and, if so, what improvement in properties could be obtained with normal gunmetals and bronzes?

MR. CIBULA replied that he would think any columnar structure was suitable, irrespective of the width of the columnar grains, as far as pressure-tightness was concerned.

A MEMBER asked, in connection with some particular work which he was doing, whether the Author would recommend refining the grain-size or on the contrary having a columnar structure.

THE AUTHOR said the speaker would probably obtain the greatest pressure-tightness if he used a high casting temperature and obtained a columnar macrostructure, but he should bear in mind Mr. Blanc's remarks about machining, for if he removed more than about 10 or 20 per cent. of the section thickness, he would machine into the pipe or centre-line porosity and the columnar structure would then, of course, be unsuitable.

Directional Solidification

MR. J. O. EDWARDS (Canadian Department of Mines and Technical Surveys) said he assumed that if one could get strongly directional solidification one might be able to overcome layer porosity. When casting cylindrical bushes, for instance, it might be very beneficial to grain refine, provided one could ensure directional solidification. He would be interested to hear whether or not Mr. Cibula agreed.

MR. CIBULA said if the feeding were better than it was in a DTD-type test-bar, then one might eliminate layer porosity. Presumably Mr. Edwards was thinking of chilling; in that case, if one could avoid the layer-porosity defect, grain-refining would almost certainly increase the strength of the alloy though perhaps reducing its ductility.

Minor Elements

MR. T. KROGVIG (Norway) said Mr. Cibula's investigations seemed to prove that the columnar structure was best, but presumably he had used mostly pure alloys, knowing what was in them. On the other hand, almost all ingot metals were melted from scrap and often the impurities were quite near the maximum permissible limit or possibly above it. Presumably there would be some difficulty with regard to small amounts of " foreign " elements, and it would be interesting to hear whether the Author had any experience of that.

MR. CIBULA, in reply, said if the alloy contained an impurity which segregated largely to the grain boundaries, grain refining should help to overcome its bad effects. Most impurities, however, would have a similar distribution to that of the eutectoid in gunmetal, *i.e.*, they would lie between the arms of the dendrites (around the cells) within the grains; in general, grain-refining did not alter the cell size in a cast structure and therefore would not improve the distribution of this type of impurity.

To sum up, he would say that grain-refining would not eliminate the bad effects of most impurities in gunmetal, but in a metal such as pure copper, where the impurities very commonly segregated to the grain boundaries, grain-refining might help considerably.

Importance of Chilling

MR. G. J. ROGERS said it had been his experience that if one grain-refined by chilling, one got better pressure-tightness in copper-base alloys. Indeed, by thoroughly chilling in a proper manner, one could produce a sound casting. In that connection he had had one startling experience years ago. Sand-cast, solid gunmetal sticks were being made for the production of nipples for evaporator coils; these were heavily machined, because the cost of making separate castings, and machining them individually, was prohibitive. These sticks were of 3-in. dia. and machined internally and externally, with the main part reduced to $\frac{3}{8}$-in. thickness. They were then tested to 1,200 lb. per sq. in. pressure and possibly not one in 20 ever withstood that test. The founders had tried using up to 14 per cent. tin content, without consistent success. Then they had started chill-casting and had used 87/8/5—8 tin and 5 zinc-alloy instead of the more expensive gunmetal. Since then, some tens of thousands of castings had been made and he could not recollect any having failed the test. Surely anyone who had made heavy non-ferrous castings, in sand moulds, would have experienced the fact that if one progressively chilled, and thus grain refined, one would get a pressure-tight casting.

MR. CIBULA, could not, of course, disagree that increasing the soundness of an alloy by chilling would improve its properties. The method of chilling might also refine the macrostructure but, in the case described, he thought the improvement in properties could be ascribed directly to the reduction in porosity rather than to grain-refinement; in other words, if chilling could have been accomplished without refining the grain-size, the same improvement in properties would probably have been obtained.

Mass Effect

MR. FRANK HUDSON, F.I.M., said he was reading the title of the Paper in rather a different way: As a practical man, his interpretation was " Influence of Grain Size on the Structure, Pressure-tightness and Tensile Properties of Bronze and Gunmetal Castings." He knew from Mr. Cibula's viewpoint the title was as stated, but he would like to ask the Author whether he felt the conclusions reached in his research applied to the production of the larger type of bronze and gunmetal castings, and he was thinking particularly of sections of 2-in. and over in masses of from 5 to 20 tons in weight, where the

mass effect would promote a very coarse grain-size indeed—far coarser than anything described in the Paper—and he wondered whether in such cases grain-refining might not possess some advantages. It would be interesting if Mr. Cibula could say how his conclusions might apply to the production of very large bronze and gunmetal castings.

MR. CIBULA, in reply, said it was probably true that with very large castings one machined off a great deal of the sound skin and the sort of difference between coarse- and fine-grain alloys that had been observed in his work would therefore not be apparent. That was a similar effect to that suggested by Mr. Blanc.

MR. HUDSON, following Mr. Cibula's remarks, said he would like to suggest that before the work was completed by the British Non-Ferrous Metals Research Association, they might do a few tests on sections where the cooling rates were very long, and where one would get very large grains of at least ⅜-in. dia., to see whether or not the advantages of grain-refining for larger castings might not be more apparent than they appeared to be where the present results were concerned. It would seem that there might be some advantage in doing a little work in that direction: he had been disappointed that the effects of fine-grain were not of more direct advantage to foundrymen and thought there must be some advantage somewhere if one could only find it.

On the motion of the CHAIRMAN (Mr. J. Bell), a very hearty vote of thanks was accorded to Mr. Cibula for his stimulating Paper and the discussion was then closed.

Oil Fuel in Power Generation

The South of Scotland Electricity Board, which has a big programme of extensions in its present generating plans, intends to make increasing use of oil instead of coal. Speaking at a luncheon following the official opening of extensions at the board's Clyde Mill generating station, Mr. J. S. Pickles, chairman of the board, said that the board was supporting the research at present going on into the use of peat in gas turbines. At the Barony station in Ayrshire, which would come into commission next September, slurry would be used.

Mr. Pickles also referred to the more economical burning of coal. The more modern the generating plant and the more advanced it was in design, the less coal was necessary per unit generated. At Clyde's Mill, for example, the first sets installed in 1916 used 3 lb. of good coal per unit, while the new ones burned less than 1¼ lb. of inferior coal. It was confidently expected, he said, that those installed at a large new station in Kincardine would use only 1 lb. of coal per unit.

He pointed out that over the whole industry the Central Electricity Authority claimed that during the past seven years improvements in generating efficiency had saved 18,000,000 tons of coal, and the North of Scotland Hydro-Electric Board claimed that its water power was saving about 700,000 tons of coal a year.

THE APPOINTMENT is announced of Lambert Bros., Limited, London, E.C.3, as agents in the United Kingdom for the Taikoo Dockyard & Engineering Company of Hongkong, Limited. John Swire & Sons, Limited, will continue to act as Taikoo Dockyard's general representatives in London.

New Equipment

Electric Capstan

A Lo-Hed model electric capstan has been developed by Taylor Stoker Company, Limited, 189/191, Drummond Street, London, N.W.1, primarily to provide a simple, inexpensive alternative to the use of a locomotive for shunting wagons on sidings, but there are many other uses, including pulling skids or heavy industrial equipment, hauling fixtures and products in straight-line assembly, kiln cars, foundry store bogies, hauling heavy castings, etc., bending pipe, dragging timber over ground, shore landing of boats, etc. It can be used for pulling anything that will roll or slide, on the level or up inclines and (by the use of fairleads or guide rollers) around curves or corners.

Important features are an unobstructed vertical barrel which allows free handling of the rope from any angle, and the fact that the entire capstan is self-contained above ground level, so that there is no necessity for excavation. The capstan is weatherproofed for operating out-of-doors, and is supplied complete with a 5-hp motor. The starting pull is 5,000 lb. and the single-line speed 45 ft. per min. when the load is on the move. It is capable of pulling wagon-loads of more than 100 tons at a time on a level track.

Overall dimensions are only 1 ft. 9 in. wide by 2 ft. 6 in. long by 2 ft. 2 in. high, and the weight approximately 5 cwt.

Finned-tube Heater

General Electric Company, Limited, have developed a finned-tube heater which combines a high rating with a large surface area. It is particularly suitable for industrial ovens and drying rooms where temperatures of 90 to 180 deg. C. are required. In natural-convection ovens working between such temperatures the heater has an operating surface temperature of about 260 deg. C.

The heater comprises a mild-steel tube with a crimped gill, of 4 in. o.d. This tube houses a withdrawable spiral element, operating at low temperature, carried on insulators which are assembled on a metal runner. The tube is of heavy-gauge steel and weighs about 7 lb. per ft. run. A mild-steel connecting box is provided at one end of the heater, with a bracket for conduit entry at the base. Automatic temperature controls for controlling room or oven temperature can be supplied as required.

Recent Wills

ROGERS, LT.-COL. H. S., former president of the Institution of Structural Engineers £5,275

THACKERAY, E. J., for many years clerk to the Faculty of Metallurgy at Sheffield University £703

BLOCH, PAUL, senior partner of Paul Bloch & Company, metal merchants, etc., of London, E.C.3 ... £89,399

SUMMERHILL, JAMES, former chairman and managing director of James Summerhill & Company, Limited, makers of iron and steel sheets, etc., of Wolverhampton £103,766

BREARLEY, LOUIS, joint managing director of P. & C. Garnett, Limited, textile-machinery manufacturers, of Cleckheaton (Yorks), and a director of William Bywater, Limited, textile engineers, of Leeds £3,564

IT IS REGRETTED THAT, in the JOURNAL of October 20, Mr. Frederick Pickworth was described as having been appointed "president" of Vickers, Limited. Actually, he has been made a director.

Notes from the Branches

East Midlands

The opening meeting of the session of the East Midlands branch of the Institute of British Foundrymen took the form of a visit to the Holwell Foundry of the Stanton Ironworks Company, Limited, where the branch president, Mr. H. P. Millar, is the manager. Approximately 130 members took part in the visit and were welcomed on behalf of the company by the office manager, Mr. D. J. Drake. The visitors saw the making of pipe specials, joint components and railway chairs in a fully mechanized plant; ingot moulds, jobbing pipes and cylinders, doffers and rollers for the textile industry, the latter being cast in what was once a shop producing vertically cast pipes 12-ft. long up to 27 in. dia., and in circular pits of unique design.

After dinner in the works canteen, Mr. Millar was invested with the presidential badge of office by the retiring president, Mr. D. W. Berridge. This was followed by the presidential address, Mr. Millar using "Control" as his theme. The following is taken from his remarks:—

"Control"

"The Chancellor of the Exchequer's target of doubling the standard of living in 25 years calls for a positive move towards much greater productivity. The history of founding indicates how the future of a considerable portion of the industry will inevitably depend on improved control. Steam provided, for the first time, power which called for man's control. The electric motor and the internal combustion engine were the main power supplying units as the 20th century dawned. Compressed air as a new source of power was then available and Herman's jolt-type moulding machines were soon pneumatically operated.

"Now that mechanized methods of production were available, much more control was possible of the dimensional accuracy of quantity production. The operator still had to operate, feed sand into, and finish moulds, supplementary to this new aid to production. Improvement in the quality of the mould materials followed and the next logical step was that sand should be conveyed to the machines and the product of the machines mechanically removed to the next station. The mechanized foundry was born. It was this type of unit—embodying sand supply—moulding machines—power conveyor—mechanical knock-out—box return—sand return, etc.—which carried all 1939-45 quantity production.

"Mechanized foundries contain several very important control linkages which in future, with the aid of electronic computers, servo-merchanisms and photo-electric cells, will be made automatic. With automatic units, the worker will no longer be an operator but a controller. Many of our plants are controlled by hydraulics. Hydraulics can be described as the brawn and since electronics can be referred to as the brain, the control cycle is complete.

"How will 'automation' affect the foundry industry? Mechanized foundries will be slowly made completely automatic. The jobbing foundry must obviously remain; more standardization of products must inevitably come about. Output in the quantity production range will become an ever-increasing percentage of the whole. The electronic computer will know only one way to make a product, so foundries can expect an advance in quality due to the complete control obtainable from the new tools.

"Labour adjustment will be a difficult problem, because of the fear of unemployment. Let us hope that Mr. Butler's target will be achieved without the heartaches which accompanied and followed the first Industrial Revolution. 'In the words of Lord Salisbury —' There is nothing new in automation. It is nothing more than a further extension of the mechanization of industry begun by the first Industrial Revolution'."

The senior vice-president, MR. H. HAYDEN, in calling for a vote of thanks to the new president, wished him a successful and happy term of office.

MR. JACK HILL, a past-president of the branch, replied on behalf of the visitors to the welcome given earlier by Mr. Drake. The evening concluded with light entertainment.

Newcastle-upon-Tyne

In an effort to encourage foundry apprentices to attend meetings, the Council of the Newcastle-upon-Tyne branch of the Institute of British Foundrymen, arranged a special meeting at the new buildings of the Rutherford College of Technology on October 17. The Council thought it probable that the regular meeting night—Saturday evening—might be unsuitable for younger members of the foundry industry and, as an experiment, arranged this week-night meeting. Unfortunately, probably due to lack of advertising, only about 20 attended the meeting, which was opened by the branch president, Mr. C. Nicholls.

A film on gating, which was to have been shown, had been used so many times previously that it had become frayed and unsatisfactory for further use, and three films covering coremaking, the making of a mould in a three-part flask, and modifications in patternmaking for quantity production of a casting, were substituted. Their presentation occupied about 1½ hrs.

In the film on coremaking, the main points emphasized were: The need for careful grading for grain-size of the sand; accurate mixing with the cereal and/or core-oil and water—dried sand being used for preference, so that the added water would give the required moisture content; working in co-operation with the laboratory, and using measuring appliances in the foundry to coincide with the results obtained in the laboratory and by trial and error; effecting economy in the use of artificial bonds, and venting of cores.

The film dealing with the mould prepared in a three-part box showed a pattern designed to leave its own core—one which would be suitable for when a few castings were required at a time. The next section illustrated modifications in the design of this pattern to facilitate quantity production. By parting the pattern and making a corebox, it was possible to use a two-part box and adequate provision was made to ensure that the core could be inserted only in the correct way.

Board Changes

HENRY BERRY & COMPANY, LIMITED—Mr. D. Coles has been appointed a director.

RYE-ARC, LIMITED—Mr. H. S. Yelland, marine manager, has been appointed to the board.

SANDERSON BROS. & NEWBOULD, LIMITED—Mr. G. S. Samways has been appointed to the board.

SOLARTON ELECTRONIC GROUP, LIMITED—Mr. R. A. Henderson and Mr. J. L. E. Smith have joined the board.

RAILWAY & GENERAL ENGINEERING COMPANY, LIMITED—Lord Kershaw has been appointed an additional director.

HUNSLET ENGINE COMPANY, LIMITED—Mr. F. Theakston, a director of Robert Hudson, Limited, has been appointed London director of the company.

German Foundry Technology

Synopses of Papers presented from September 22 to 24

In September, at the 46th annual meeting of the German Foundrymen's Association (Verein Deutscher Giessereifachleute) *in Dusseldorf, a number of papers were given which have significant interest for British founders. Synopses of these, which give an insight into current trends in foundry technology in Germany, are printed in what follows:—*

Induction Melting

By Dr.-Ing. K. Brokmeier

Economic working of induction-melting furnaces in the foundry is only possible when their potentialities, basic conditions and limits are clearly understood. The first part of the paper therefore surveys the methods of operation and the peculiarities of the induction-melting method, compared with other processes and using experimental material as well as illustrations for further explanation. The paper restricts itself to those questions which are of interest to the foundry from the metallurgical, working and economic points of view.

The second part describes the application of the various designs of induction furnaces for the whole field of metal melting. Publications and experience of both foreign and home practice are discussed and outstanding plants are illustrated. The paper gives a survey of the possibilities of construction and design of induction-melting plants.

Production of Malleable Castings by Gaseous Annealing

By Prof. Dr.-Ing. K. Roesch

The production of malleable iron is the most expensive metallurgical process in the iron industry. On account of the high annealing temperature and several days of soaking, the heat consumption is very high. Considerable costs are also incurred in the old process by the rapid wearing out of boxes due to scale formation and by the consumption of iron ore during the treatment.

As the annealing of the iron castings in iron ore is, in fact, decarburization *via* the gas phase, this led to the idea that the annealing process could be carried out in a gas mixture of CO and CO_2. In the process developed jointly by the Bergische Stahl Industrie and the furnace firm Indugas at Essen the iron castings are annealed at 1,050 deg. C. in the controlled gas-atmosphere of sealed furnaces, which are heated indirectly by radiant-tube heaters.

Atmosphere

The atmosphere consists of 8 per cent. CO_2, 24 to 26 per cent. CO, 26 to 28 per cent. H_2 and about 11 per cent. H_2O. Its reactivity is kept at a constant level by feeding in of hot-air saturated with steam, as otherwise the CO content would become too high and the decarburization would come to a standstill. The castings are packed into light, perforated boxes without any iron ore. As the composition of the gas atmosphere mentioned is in equilibrium with the final carbon content of 0.1 per cent. C., neither the casting nor the boxes can develop scale, however long the annealing might be prolonged.

This gaseous process is considerably cheaper than the older method not only because of the lower cost of boxes but also by replacing iron ore by steam saturated air. There is also a saving of time as there is no need to heat unnecessary ballast. The transport of the boxes is effected by a compressed-air drive which delivers them to tunnel furnaces and pushes the boxes forward in regular intervals of about one hour. A hydraulic control-system switches the lifting or lowering of the boxes automatically in conjunction with the compressed-air drive. After several years of development work, a tunnel furnace of this kind has been in operation at the Author's works for a year without interruption. As this plant has proved to be satisfactory, several similar tunnel furnaces are now under construction.

Ductile and Brittle Fracture in Ferritic Nodular Irons

By H. Morrogh and G. N. J. Gilbert,* A.M.I. Mech.E., Birmingham*

The general features of ductile and brittle failure in ferrous materials are discussed. Ferritic nodular irons behave essentially the same as other ferrous materials. Impact transition curves for nodular irons of various silicon and phosphorus contents are given. In the ductile condition, ferritic nodular irons have a black fracture and in the brittle condition, a bright crystalline fracture. The combined effects of silicon, manganese and phosphorus, and the effect of nickel on the impact properties were studied, using fracture appearance and impact value as a criterion of ductility. The decomposition of pearlite by heat-treatment below the critical range and without normalizing has been shown to give an embrittling sub-boundary structure. The temper-embrittlement of nodular irons is also discussed.

The mechanism of fracture in notched and unnotched specimens is dealt with. Much energy is used to initiate fracture in unnotched specimens in which there is a release of stored elastic energy which accelerates fracture propagation and may cause a change from ductile to brittle fracture. Relatively little energy is required to start a crack in a notched specimen. The notch provides triaxiality of stress which raises the transition temperature. In notched specimens, the fracture is propagated at the same speed as the hammer.

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* British Cast Iron Research Association

German Foundry Technology

Present State of Development and Application of Nodular Iron

By Dipl.-Ing. K. Figge

After reviewing the world production of nodular iron, it is suggested (and reasons are given) that this material constitutes a separate class of engineering materials. Starting from the special analysis methods for nodular iron, the methods for the selection of raw materials and melting charges are mentioned. American and German conditions are compared. The present knowledge regarding Mg-treatment is stated and the choice of metallic Mg-carriers as well as the introduction of pure magnesium are discussed. In future, it is stated, nodular iron will be produced which is mainly nickel free. In the majority of cases it will be delivered in the heat-treated condition and foundries will have to equip themselves accordingly. Several grades can be obtained by heat-treatment and further fields of application are developing.

On the American market, seven different grades of nodular iron are already obtainable, and it will soon be necessary to introduce German standard specifications for nodular iron. Finally, based on examples from all over the world, the properties and fields of application are discussed.

Influence of Some Elements on the Formation of Nodular Iron

By Prof. A de Sy and Johan Verelst.

The authors investigated the influence of the elements Al, Cu, Bi and Pb on the crystallization of graphite in magnesium-treated cast iron. Four series of experimental melts were made, using Swedish pig-iron and steel scrap. The melting was carried out in a medium-frequency induction furnace, with increasing additions of the metals mentioned. Results were judged by inspection of micrographic sections and by testing of the mechanical properties obtained after normalizing. Attention was given to the problem of possible segregation, especially applicable to copper, as this might have an unfavourable influence on the crystallization of the graphite nodules. An electrolytic-impression method was developed to determine the effects of such segregations.

The results of these experiments form the basis for some theoretical considerations with regard to the growth of nodular graphite; the mechanism of diffusion and distribution of interfering elements, and the mechanism of derangement.

Effect of Inoculation on the Crystallization of Metal Melts

By Prof. E. Scheil

There is a definition of inoculation as a means for the formation of nuclei by intentional (inoculation) or unintentional additions to metal melts. The theories of nuclei formation by R. Becket and of stationary distribution of sub-nuclei in the melt are quoted. Also dealt with are the importance of nuclei formation work and comparison with the energy necessary to start a chemical reaction; the reduction of nuclei formation work by inoculants, and analogy with the action of a catalyst on a chemical reaction, also the essential difference between the two processes. The growing-on of crystals on a crystalline base of a different type is described as a thoroughly investigated example of inoculation effect. Inoculation and inhibition of inoculants; and the overriding importance of the number of inoculation particles for obtaining grain refinement conclude this section, and, finally, the modification of 12 per cent. silicon/aluminium alloy is described as an example of the technical importance of inoculation inhibition.

Viscosity of Melts in Relation to Castability

By Dr. T. P. Yao

The author has developed a new torsion viscometer for the estimation of the viscosity of liquid metals. The results obtained by gauging this viscometer with liquids of known viscosity show that the logarithmic decrement does not steadily increase with increased viscosity but that a limit value exists. Beyond this limit value, the logarithmic decrement decreases with still increasing viscosity. To describe this phenomenon, a new expression has been coined: namely, the "glue effect." The estimation of the viscosity of various pure metals confirmed that the viscosity alters considerably at and near the temperature of solidification. The author surveys the castability of various metals and alloys in relation to casting temperature. He states that the viscosity/temperature curves appear to be symmetrical to the castability/temperature curves.

Comparison between the viscosity and the castability of binary systems such as tin/zinc, aluminium/copper, aluminium/silicon, aluminium/zinc, lead/tin and antimony/cadmium shows:—(*a*) That pure *components* as well as their *eutectic alloys*, generally combine a minimum of viscosity with a maximum of castability, and (*b*) that *alloys of components with maximum solid solubility* combine a maximum of viscosity with a minimum of castability. *Intermetallic compounds* distinguish themselves generally by a high viscosity and in some cases also by a good castability. Theoretical considerations regarding the relationship between viscosity and atomic structure of the metals show that there exists a nearly linear relationship between: (1) viscosity and melting point, (2) viscosity and heat of fusion, and (3) viscosity and surface tension, as far as unalloyed metals are concerned. A periodic relationship also exists between the viscosity of various metals and their atomic numbers. When plotting the viscosity against the atomic volume or the viscosity against the crystal lattice of various metals, a parabolic curve will be obtained. Finally, the viscosity is nearly directly proportional to the difference between atomic radius and ion radius of various elements.

The results confirm the view that the forces of cohesion and the arrangement of the atoms of liquid metals (especially near the melting point) are very similar to those of solid metals. It is possible to establish a mathematical equation for the calculation of the viscosity of many metals and their alloys.

Present Knowledge of the CO_2 Process

By Dr.-Ing. W. Schumacher

After a short review of the development of the CO_2 Process in Germany during recent years, the author discusses the foreign literature on this subject, especially mentioning two valuable contributions in an Austrian and an English periodical. This is followed by a report on his own experiments carried out for estimating the heat conductivity of CO_2-hardened sands. The conclusions drawn from this investigation were of help in a practical workshop case. Based on extended foundry investigations, the connections between core knock-out, fettling time and strength values of the sands are explained and the influence of the sand mixture, the dressing used and the cooling-off time on the strength values of the sand are mentioned.

Gas Evolution

The author also describes his investigations regarding the measurement of gas evolution from CO_2-hardened sands in comparison with customary moulding sands. The re-use of hardened sand viewed from the theoretical as well as practical point of view is discussed.

Finally numerous practical examples are shown which demonstrate the application of the CO_2 Process in aluminium and magnesium as well as iron and steel foundries. The economic advantages of the CO_2 Process are said now to be well established.

Mechanical and Technical Properties of the Aluminium Alloy: G AlSi 6 Cu 3 (225) (with larger variations of the concentration of the alloying elements)

By Dipl.-Ing. O. Asbeck

A short introduction into the literature and discussion of the theory of hot-shortness, mould-filling capacity and grain refinement is followed by an examination of the effects of varying the concentration of the alloying elements silicon, copper, magnesium and zinc within the range of specification for the German alloy G A1Si 6 Cu 3 (aluminium casting alloy with 6 per cent. of silicon and 3 per cent. of copper, nominally). The influence of these variations on the mechanical and technological properties is described, in comparison with earlier experiments.

Experiments on the problem of hot-shortness gave the following results: Tendency to hot-shortness increases with increased casting temperature but declines with increasing temperature of the die. Tendency of hot-shortness is increased with rougher surfaces of moulds or dies. A similar influence is effected by increased zinc or magnesium contents, even within specification limits, but increased silicon reduces the tendency for hot-shortness; grain refining preparations containing boron and/or titanium, also reduce the tendency.

Investigation of the mechanical properties of the series of aluminium alloys led to the following conclusions: Within the tolerances of the specification, and even beyond these, the zinc content has no influence on tensile strength and hardness but slightly improves the elongation, both in the as-cast and in the heat-treated condition. Increased magnesium contents within the specification limits improve tensile strength and hardness but impair elongation. Within the limits of the specification, the alloy 225 can be improved by heat-treatment in regard to tensile strength and hardness at the expense of elongation.

By comparing two alloys which are being submitted for standardization by the *VDG* "technical sub-committee for light metals," the following differences between the alloys of the type G AlSi 6 Cu 4 and type G AlSi 7 Cu 3 can be noticed: The alloy G AlSi 7 Cu 3 is less sensitive to hot-shortness; and tensile strength, elongation, hardness and impact value are higher than equivalent values for alloy G AlSi 6 Cu 4. The former alloy also possesses a much better mould-filling capacity than the latter. Both alloys were subjected to grain refinement by boron and titanium additions. Grain refinement was found by the author to reduce danger of hot-shortness and also to improve tensile strength, elongation, hardness and mould-filling capacity.

Industry and Human Relations

The increasing extent to which the craftsman has been replaced by the machine minder has resulted in the minder's being able only to see himself as a part of the machine he minds and unable to recognize his importance in the total scheme of things. Sketching this picture at the annual luncheon of the Guild of Cordwainers in London recently, Sir Walter Monckton, the Minister of Labour, said that there had been a tendency to think too much in terms of the machine and too little in terms of the individual and the value of human qualities.

But while the Minister thought we had been lagging behind in our thinking about human problems, he welcomed the increased interest in the subject being shown in industry as one of the most encouraging trends of our time. The two facets of labour relations—industrial relations and human relations—exerted considerable influence on one another. Where human relations were satisfactory a reservoir of goodwill and co-operation existed, from which incalculable good could flow.

Sir Walter believed that the pattern of industrial life had profoundly affected the relationship between man and man, making management's responsibilities greater than ever before. In essence, the problem was one of adjustment to the requirements of changing conditions, helping people to find in their working environment opportunities for satisfactory personal contacts, and to discern an objective that was wider than the one provided merely by the jobs they were doing.

British Trading Position

Mr. Errol, Parliamentary Secretary to the Ministry of Supply, in an after-dinner speech to the recent International Enamelling Congress organized in this country by the Institute of Vitreous Enamellers, said that his Ministry was one of Great Britain's most substantial manufacturing organizations. The Royal Ordnance Factories employed nearly 60,000 people; they made a wide variety of highly skilled engineering products and also an important range of chemicals and explosives: an essential part of the various types of ammunition which were finally manufactured at others of the Government factories. Coming to this Department within the last few months from industry, he had been most impressed by the efficiency of these factories and by the team spirit which existed, not only in the factories themselves but in the Ministry of Supply organization as a whole.

The United Kingdom, as everyone knew, was vitally dependent on its export trade. There were 50 million people crowded into a small island with few natural resources. The country had to import in order to provide food and the raw materials needed to keep industries working. Imports accounted for about one-fifth of the total resources. Practically all the raw materials (apart from coal, limestone, salt and china clay) were imported as well as about half the food consumed. The only way to pay for these imports was by selling goods overseas. The country had also to meet big bills for military commitments abroad and would like to regain its position as an overseas investor. It was, however, not only in British interests but in the interests of the world as a whole that, this country should increase its exports and thereby maintain full employment at home and increase the standard of life of the people. However, there was another side of this picture. As one of the world's greatest buyers, the United Kingdom took 12 per cent. of the world's imports, and many countries depended on British imports from them for their own internal prosperity. So when other countries bought from Britain they were enabling this country in its turn to buy the raw materials which they have to offer.

How successful had the country been in meeting this challenge to increase exports. On the whole he thought it had done very well. At the end of the war the export trade was at about one-third of its pre-war volume. By 1954, the volume of exports was two-thirds higher than before the war. At a value of over £2,600 million they were in 1954 an all-time record. After the United States, Britain was still the largest exporter of manufactured goods and exports accounted for about 20 per cent. of the world's exports of manufactures. To achieve this expansion, British industry had had to be adjustable and flexible and ready to meet the changing trend of world trade. Many countries were setting up their own industries, particularly to produce the smaller types of manufactured goods, and so the emphasis had naturally been on an even greater demand for capital equipment of all kinds —particularly from the less developed countries, which were embarking on large scale development plans. Thus, engineering goods accounted for nearly 40 per cent. of the export trade last year, compared with 24 per cent. before the war.

While Britain was still exporting strongly its traditional goods, there had been an impressive development in exports from industries which either did not exist in Britain before the war or which did not attempt to export prior to 1939. He mentioned a few, such as: radio, television equipment. fork-lift trucks, agricultural machinery, nylon goods, and pharmaceutical products. These, with a number of others, accounted for about 11 per cent. of the export trade and showed how effectively the country had moved with the times and had maintained a leading position in many fields of scientific and technical development. One thing Britain had learned was that the world did not owe this country a living. If the United Kingdom was to hold on to and increase its share of world trade it must be fully competitive. Competition from other industrial countries had been increasing but he believed it could be met by providing the goods customers needed at the right price and at the right time.

Much was heard to-day about the shortcomings of British exporters, particularly as regards delivery promises; but this nation expected things to be done properly and it rightly concentrated its attention on the much publicized but relatively few examples of its shortcomings. The vast number of contracts which were completed on time never received publicity; it was the odd contract, where something had gone wrong, that made the news, and often enough there was a good reason, such as a change of requirements on the part of the customer, to explain the delay. The same might be said of new orders. A foreign firm securing an order in a traditional British market usually received more publicity in the Press than when exporters succeeded in breaking into new markets they had not hitherto entered.

British success both abroad and at home had produced problems of its own—the problems of prosperity —the problem of wanting to have just that much more for home consumption than could be now afforded. The Chancellor of the Exchequer had made it plain on several occasions that the Government would not shrink from taking all steps necessary to keep the British economy sound and in good shape. Inevitably there must be from time to time some little ups and downs. As long as Britain was able to trade successfully and on a large scale throughout the world he was sure that this island would continue to maintain its high level of prosperity.

New Catalogues

Cupola Dust and Spark Prevention. A four-page leaflet received from Prat-Daniel (Stanmore), Limited, Dalston Gardens, Stanmore, Middlesex, illustrates and describes a simple design of dust- and spark-arrester for attachment to the cupola. A cylinder with an open top and sloping floor is built around the top of the cupola. About midway up the cylinder a shallow cone is fitted, and on to the central part of this plays a water jet, which according to the diagram forms a double water curtain. With this pamphlet came others covering dust collectors and fans: they are available to readers on writing to Stanmore.

Tandem News, No. 17. Issued by the Eyre Smelting Company, Limited, Merton Abbey, London, S.W.19.

There is an interesting description in this issue of the centrifugal casting of low-melting-point alloys into rubber moulds for the production of imitation jewelry, toys and the like—with the possibility of making engineering components. The particular problems which have been studied by the research department of this company has been the *élaboration* of suitable alloys. There is still available a number of copies of this issue for readers.

Personal

Mr. PERCY ELLIOTT, secretary of the Butterley Company, Limited, Ripley, Derbyshire, has been appointed a director. He has been associated with the company since 1915.

Mr. M. J. GLENNY, Dover Engineering Works, Limited, has been appointed vice-chairman of the Council of the Ironfoundry Association. He replaces Mr. P. L. GOULD, O.B.E., who has resigned his business association with ironfounding.

AFTER 57 years' association with the company, Mr. E. W. HOLLOWAY, chairman and managing director of Matterson, Huxley & Watson, Limited, ironfounders, steel stockholders, constructional engineers, etc., of Coventry, is to retire at the end of the year.

THE assistant works manager of the light-castings department of Newton, Chambers & Company, Limited, Thorncliffe, near Sheffield, since August last year, Mr. F. S. COX, has been appointed works manager of the department. He joined the company in 1952 as pattern-shop manager in the light castings department.

Mr. J. GLYN JONES has recently joined the technical sales staff of the Sheepbridge Group and will represent Sheepbridge Alloy Castings, Limited, and Sintered Products, Limited, in the north-western area. He will operate from 48, Rydal Avenue, Sale, Cheshire. Mr. Glyn Jones was previously with P.I. Castings, Limited, Altrincham.

J. W. JACKMAN & COMPANY, LIMITED, announce that after 43 years' service with the company, Mr. W. R. RAWLINSON desires to retire from active managing directorship and at the last director's meeting MR. F. W. NEVILLE was appointed managing director as from November 1. Under the new arrangement, Mr. Rawlinson becomes vice-chairman.

AT A MEETING of the Court of the Worshipful Company of Shipwrights, Sir JAMES M. MCNEILL, deputy chairman of John Brown & Company (Clydebank), Limited, and president of the Shipbuilding Conference, was sworn in as assistant to the Court. The Queen's Medal was presented to Mr. THOMAS ROBERTSON, an apprentice with Sir James Laing & Sons, Limited.

THE CHAIRMANSHIP of the Export Committee of the British Internal Combustion Engine Manufacturers' Association was assumed on Tuesday by Mr. KENTON REDGRAVE, deputy chairman and managing director of Russell, Newbery & Company, Limited, Diesel-engine makers, of Dagenham (Essex). He is also managing director of Sterling Electric Holdings, Limited, the Sterling Engineering Company, Limited, and Electrix, Limited, all of Dagenham.

LEY'S MALLEABLE CASTINGS COMPANY, LIMITED, celebrated recently the coming of age of Mr. IAN LEY, great-grandson of the founder of the firm, by entertaining to dinner over 1,050 employees with long service. Mr. Ian Ley was presented with a pair of silver tankards. After the dinner Mr. Francis Ley distributed 108 clocks and watches to those who had this year completed their 21 years' service, and eight long-service certificates for 40 years.

THE BOARD OF WALMSLEY (BURY) GROUP, LIMITED, pulp and papermaking machinery manufacturers, announces that Mr. JOHN WOLSTENHOLME has resigned, on the grounds of age, his position as chairman. He has been appointed president as some recognition of his lifetime's service. Mr. Wolstenholme remains an ordinary director of all companies within the group. Mr. ALAN GREEN, who is already chairman of the five operating subsidiary companies, has been elected chairman of the Walmsley (Bury) Group, of which he was previously deputy chairman. He is MP for Preston South. A textile manufacturer, Mr. Green was born in 1911 and educated at Brighton College and London University.

Obituary

Mr. WILLIAM HENRY FROST, managing director of W. H. Frost & Company, Limited, precision engineers, of Burnley (Lancs), died on October 22 at the age of 78.

Mr. WALTER STUBBINGS, works manager of Herbert Terry & Sons, Limited, Redditch, Worcs, has died at the age of 71. He was with the firm for more than 56 years.

Mr. ALFRED JOHN FRANKLIN, secretary of Armstrong Siddeley Motors, Limited, Coventry, was killed on October 27, in a car accident at Ryon Hill on the Warwick-Stratford-on-Avon road. His four young passengers, including his twin sons, were severely injured.

THE SUDDEN DEATH occurred at Grange-over-Sands of Mr. HAROLD TOWN, of Halifax, at the age of 67, Prior to his retirement Mr. Town was a director of Frederick Town & Sons, Limited, ironfounders and machine tool makers, Mile Cross Works, Halifax, which was founded by his father.

THE DEATH IS ANNOUNCED of Mr. E. J. PARLANTI—a well-known art founder—at the age of 84. He was responsible for many of the notable pieces of statuary in this country, such as, for instance, the 17-ton gilt-bronze eagle—the R.A.F. war memorial on Westminster Embankment. Not only was he an art founder, but also a sculptor of eminence and, in addition, was the author of "Art Bronze Castings."

THE DEATH HAS OCCURRED of Mr. GUY L. MURRAY, a founder and first honorary secretary of the Yorkshire branch of the Institution of Mechanical Engineers. He was works manager of the old Leeds concern of Joshua Buckton & Company, Limited, machine-tool manufacturers, before taking up an appointment as superintendent of the carriage and wagon works of the Sudan Government Railways. Later he joined the staff at Cheltenham College.

THE first head of the ironmaking division of the British Iron and Steel Research Association, Dr. HORACE LEONARD SAUNDERS, died on October 14. In 1939 he was appointed special lecturer in thermometallurgy at the Imperial College of Science and Technology, London, where he built up a research team to work in the blast-furnace laboratory. This work was transferred to BISRA in 1945, when Dr. Saunders became head of the newly formed ironmaking division, a post he relinquished in April last year because of ill-health.

Sir ALEXANDER DUNBAR, who was one of the architects of the reorganization and modernization of the English Steel Corporation, Limited, Sheffield, in the 1930s, died on October 14. He was 67. With Sir Charles Craven he took a considerable part in the scheme, having joined the Board in 1933. During the last war his services were called on by the Ministry of Aircraft Production, but he was released in 1943 and rejoined the corporation's board. In 1944 he was appointed first managing director and subsequently chairman. He resigned from the board in 1946.

News in Brief

MR. JAMES TIMBRELL has changed his address to 37, Gates Croft, Calverley, Leeds.

NEVELIN ELECTRIC COMPANY, LIMITED, have moved to Hurst Green, Oxted, Surrey (telephone: Oxted 1450).

LAMBERT BROTHERS, LIMITED, have had plans approved to erect new extensions to the foundry in Green Lane, Walsall, Staffs.

VOWLES BROTHERS, LIMITED, have had plans submitted to erect a new extension to the foundry in Church Lane, West Bromwich.

THOS. W. WARD, LIMITED, Albion Works, Sheffield, are to show a new tractor for the first time at the Building Exhibition, at Olympia, this month. It is the Fowler Challenger II diesel-crawler tractor, fitted with angle-dozing gear.

FRASER & CHALMERS ENGINEERING WORKS of the General Electric Company, Limited, has received an order, valued at over £600,000, from Colvilles, Limited, for an ore-handling, -storage and -loading plant, to be installed at General Terminus Quay in Glasgow on the River Clyde.

DERBY AND DISTRICT COLLEGE OF TECHNOLOGY are to organize a course of lectures for supervisory grades (foremen, forewomen, charge-hands and overlookers). The first lecture has been arranged for November 14, and will be held in the board room at the Employment Exchange, Normanton Road, Derby.

THE MAIN civil and building contract for the atomic station at Annan, near Dumfries, has been awarded to the Mitchell Construction Company, Limited, civil engineers and contractors, Peterborough, Northants. The contract is worth approximately £3,500,000 and is one of the biggest ever received by the firm.

THE FIRST of 17 diesel mechanical-shunting locomotives has been completed at the Stafford works of W. G. Bagnall, Limited, for the New Zealand Government Railways. Ten 240-b.h.p. locomotives were ordered in May last year and last month an order was received for a further seven 150-b.h.p. locomotives. The total value of the contracts is £233,000.

THE IRON AND STEEL INSTITUTE has arranged for Sir Robert Shone and Mr. W. F. Cartwright to give a lecture on the "Russian iron and steel industry" at the Seymour Hall, Seymour Place, Marylebone, at 6 p.m., on November 16. Admission will be by ticket only and these may be obtained by application to the Institute at 4, Grosvenor Gardens, London, S.W.1.

PLANS ARE GOING FORWARD for the 1956 BIF at Castle Bromwich and Mr. Misha Black, the Mayfair designer, has been asked to give the Fair "a new look." All but 10 per cent. of the space has already been filled, Mr. Ivan Yates, chairman of the Fair Committee of Birmingham Chamber of Commerce, states. There are between 150 and 200 new exhibitors.

GRIFFIN & GEORGE, LIMITED, announce that as from November 7, all London and Southern Counties orders, enquiries and correspondence will be dealt with from their recently extended offices and warehouse at Ealing Road, Alperton, Wembley, Middlesex (telephone: Perivale 3344); the Griffin & Tatlock division at Kemble Street, Kingsway, will be closed as from that date.

QUEEN ELIZABETH THE QUEEN MOTHER on October 23 opened the doors of Reading's new technical college with a golden key and afterwards toured the four-storey building, visiting, among other sections, the engineering and science departments. The college, which has been built at a cost of £763,000, has accommodation for more than 5,000 men and women students.

MR. F. S. LEIGH, of Birlec, Limited, told steel scientists and technologists from the North of England in Sheffield on October 24, of a new type of steel melting furnace. This is the company's mains-frequency coreless furnace; similar furnaces had been developed in Germany and the United States and an agreement has now been negotiated for their joint development and marketing.

A DOLLAR CONTRACT worth more than £1,000,000 for 3,200 aluminium houses has been awarded to the Northern Aluminium Company, Limited, Banbury (Oxon), by the housing organization of the Government of Columbia. The final stages of the manufacture and packing of the houses will be carried out by A. P. Metalcraft, Limited, of Coventry and Shipston-on-Stour (Warwickshire).

THE INDUSTRIAL DIVISION of the Council of Industrial Design has been unable in the past to keep in regular touch with all the industries which will be represented at the Design Centre to be opened in the Haymarket, London, W.1, next year, according to the Council's annual report. Three new industrial officers, who will maintain personal contact with manufacturers, have, therefore, been appointed.

THE 1955 VISCOUNT NUFFIELD PAPER, "Britain's Energy Prospects," by Dr. G. H. Daniel, chief statistician, Ministry of Fuel and Power, will be presented at the Royal Institution, Albemarle Street, London, W.1, on December 15, at 6.30 p.m. Application for tickets of admission to the meeting may be made to the secretary of the Institution of Production Engineers, 10, Chesterfield Street, London, W.1.

J. W. JACKMAN & COMPANY, LIMITED, Vulcan Works, Blackfriars Road, Manchester, 3, report that they have received an order from Ford Motor Company, Limited, Dagenham, for 16 Osborn No. 1236 automatic, jolt-squeeze-strip moulding machines. The machines will be manufactured at the firm's works at Blackfriars Road, Manchester, which is being extended so that heavy machines of this sort can be dealt with.

SIR JACOB EPSTEIN, the sculptor, is to use aluminium for the first time for the huge figure of Christ which has been commissioned for Llandaff Cathedral. The figure, 16 ft. in height, is to be cast at the Lambeth foundry of the Morris Singer Company. Sir Jacob has experimented with various metals in recent years. It will be recalled that he used lead for the first time for his figure of the Virgin now in Cavendish Square.

MORE THAN £1,000,000 worth of iron pipes in the Teheran (Persia) water supply scheme, now nearing completion, were made by the Stanton Ironworks Company, Limited, and the Staveley Iron & Chemical Company, Limited, according to a statement released in the East Midlands by the Board of Trade. A further contract recently announced was for more than £2,000,000 worth of iron pipes for Egypt, to be supplied by the Stanton Ironworks Company, Limited.

MONSANTO CHEMICALS, LIMITED, announce that Hygrotherm Engineering, Limited, 37, Upper Brook Street, London, W.1 (telephone: LEGation 4111), have been appointed sole selling agents in the United Kingdom for their organic silicate range of heat-transfer fluids. Grades suitable for varying purposes over the temperature range of −73 deg. C. to 332 deg. C. are available, and full technical information will be provided by the agents.

A SURVEY of the types of employment taken up by

university graduates, based on 3,961 replies to a question paper sent out by Political and Economic Planning, shows that teaching and manufacturing industry both attract nearly a quarter of the total. But "science in the schools attracts fewer of the more highly qualified graduates," states the survey. Based on men who graduated in 1950, the survey reveals that industry as a whole accounted for 1,168, or nearly 30 per cent. of the graduates.

ACCORDING to the report on the "Enquiry into the Effects of National Service on the Education and Employment of Young Men," the majority of young men settle down satisfactorily in civilian life after doing their National Service, and the number of young men who return to their pre-Service employment is higher where employers keep in touch with them during their time in the Forces. It was found that 90.6 per cent were satisfactorily settled, *i.e.*, 80.3 per cent. were in employment and 10.3 per cent. engaged in further education.

LAST WEEK, Dr. Stanley Whithead, director of the Electrical Research Association, opened a new research laboratory at the premises of the Belmos Company, Limited, Blantyre. The new £20,000 laboratory, the first of its kind in Scotland, will enable the firm to test its products on their own premises instead of, as formerly, sending them to a testing station in England. The company, founded at Bellshill in 1919, now manufacture switchgear and control gear at two modern factories in Lanarkshire, and provides employment for 600 people.

TO COMPENSATE for recent changes in foreign exchange rates and keep the domestic price of nickel in accord with basic export price, the International Nickel Company of Canada, Limited, have announced a change of ¼ cent per pound in its price of electrolytically refined nickel, for consumption in Canada, increasing the price from 62¼ (Canadian currency) to 63 cents per pound, from its Port Colborne, Ontario, refinery. The price change does not alter the company's price of nickel for the United Kingdom, the United States, or for other markets.

"I CAN SEE no hope of general factory lighting ever serving industry as it should until a true balance is struck between natural and artificial lighting, and until we cease to treat artificial lighting as merely a necessary evil," said Mr. W. Robinson, lighting officer of the British Electrical Development Association, at Swansea, on October 27. It had been proved, he said, that the key to improved productivity was the psychology of the worker and that lighting improvements could be a powerful psychological aid to productivity even when the existing lighting was adequate for purely visual purposes.

THE ANNUAL "OPEN DAY" organized by the Ashton-under-Lyne works of the National Gas & Oil Engine Company, Limited, which employs some 2,000 people, was this year attended by no fewer than 4,000 visitors. They were the wives and children of the employees, and even the smallest of the latter were well catered for. The management believes that "open days" give added interest and pride of workmanship amongst the employees. This company each year organizes a competition for "better-housekeeping" during the Industrial Safety Week. Silver shields were presented to the winning teams by the Mayor of the town.

TWO LARGE CONTRACTS for the manufacture of Ferguson agricultural tractors and implements and Massey-Harris combines in Yugoslavia have been obtained by the Massey-Harris-Ferguson organization. F. Perkins, Limited, Peterborough, is to supply about £1,000,000 worth of engines for the tractors. Under the terms of the contract Massey-Harris-Ferguson will ship to Yugoslavia, between now and the end of this year, 900 tractors and 2,000 implements. In 1956 2,800 tractors, 9,000 implements, 11,000 accessories and about 100 combines will be despatched. Local manufacture of this equipment will be undertaken progressively under licence, it is stated.

STEPS TO PERPETUATE the memory of John Wilkinson, "father" of the Black Country iron trade, are being taken by Bilston Historical Society and a plaque is soon to be erected on a concrete cairn beside Great Bridge Road, on the site of the original Wilkinson ironworks. Appropriately the plaque is made of cast iron—members of the Society have produced it in a local foundry—and it records that this was the place where Wilkinson set up his "Fiery Holes" works, a name derived from the appearance of the locality by night. Research into John Wilkinson's Staffordshire associations is still being carried on by the Society. The ironmaster, born in Cumberland, went to Bilston in 1756.

Increases in Capital

BRADFORD GAS ENGINE COMPANY, LIMITED, Shipley, (Yorks), increased by £20,000, in £1 ordinary shares, beyond the registered capital of £10,000.

HIGHFIELD GEAR & ENGINEERING COMPANY, LIMITED, Huddersfield, increased by £65,000, in £1 ordinary shares, beyond the registered capital of £10,000.

SWEENEY & BLOCKSIDGE (POWER PRESSES), LIMITED, Birmingham, increased by £41,000, in £1 ordinary shares, beyond the registered capital of £5,000.

J. & S. EYRES, LIMITED, ironfounders, engineers, etc., of Manchester, increased by £30,000, in £1 ordinary shares, beyond the registered capital of £20,000.

FLEXELLO CASTORS & WHEELS, LIMITED, Slough (Bucks), increased by £25,000, in £1 unclassified shares, beyond the registered capital of £25,000.

WALKER BROS., LIMITED, galvanizers, etc., of Walsall (Staffs), increased by £110,000, in 2s. ordinary shares, beyond the registered capital of £140,000.

HARRIS LIFTING & SHIPPING TACKLE COMPANY, LIMITED, Old Hill (Staffs), increased by £10,000, in £1 ordinary shares, beyond the registered capital of £5,000.

POWERS-SAMAS ACCOUNTING MACHINES, LIMITED, London, E.C.1, increased by £2,000,000, in 10s. ordinary shares, beyond the registered capital of £2,000,000.

SKEFKO BALL BEARING COMPANY, LIMITED, Luton (Beds), increased by £3,500,000, in 5s. ordinary shares, beyond the registered capital of £1,500,000.

PETER WOOZLEY, LIMITED, general engineers, etc., of Richmond (Surrey), increased by £22,500, in £1 ordinary shares, beyond the registered capital of £2,500.

BIFURCATED & TUBULAR RIVET COMPANY, LIMITED, Aylesbury (Bucks), increased by £400,000, in 5s. ordinary shares, beyond the registered capital of £400,000.

CLAYTON SON & COMPANY, LIMITED, gas and gasworks engineers, of Leeds, increased by £200,000, in £1 ordinary shares, beyond the registered capital of £300,000.

SHIELD TRUST, LIMITED (formerly Shield Alloys, Limited), London, E.1, increased by £20,000, in £1 unclassified shares beyond the registered capital of £5,000.

COHEAT, LIMITED, hardware manufacturers and dealers, of London, E.C.2, increased by £10,000, in £1 ordinary shares, beyond the registered capital of £10,000.

DOWNING & MILLS, LIMITED, manufacturing engineers, etc., of Birmingham, increased by £25,000, in 1s. ordinary shares, beyond the registered capital of £50,000.

GEORGE WALKER & SONS (BIRMINGHAM), LIMITED, file and tool manufacturers, etc., increased by £50,000, in £1 ordinary shares, beyond the registered capital of £65,000.

RICHARDS (LEICESTER), LIMITED, constructional engineers and ironfounders, etc., increased by £50,000, in 5s. ordinary shares, beyond the registered capital of £150,000.

CONNIES & MEADEN, LIMITED, constructional engineers, etc., of Cardiff, increased by £40,000, in 160,000 "A" ordinary shares of 5s., beyond the registered capital of £60,000.

F. PERKINS, LIMITED, engine manufacturers, of London, E.C.4, increased by £2,700,000 in 10s. ordinary shares, beyond the registered capital of £1,300,000.

GILBERT & HUNT, LIMITED, manufacturers of bakery machinery, etc., of Huddersfield, increased by £23,000, in £1 ordinary shares, beyond the registered capital of £2,000.

FRY'S (LONDON), LIMITED, mechanical and electrical engineers, etc., of Southwark. S.E.1, increased by £40,000, in £1 ordinary shares, beyond the registered capital of £30,000.

Raw Material Markets

Iron and Steel

Production of pig-iron has now fully recovered from the setback it received from the rail strike, when shortages of raw materials reduced outputs at many blast furnaces and stopped production completely at some. Since that time deliveries of ore from abroad have been at high levels, and supplies from home sources have increased, while coke deliveries have been in adequate tonnages to burden the furnaces. With the new furnaces recently blown in, and others put into blast again following relining and repairs, overall outputs are again reaching record levels.

Basic steelmaking pig-iron represents about three quarters of the total production, and is contributing largely to the impressive outputs which the steelworks continue to maintain, although the tonnages which home furnaces are able to supply still have to be augmented with supplies of imported iron. New furnaces to be blown in later in the year will raise deliveries to the steelworks, and may possibly reduce the need for deliveries from abroad.

Foundry grades of pig-iron show a wide variation between supply and demand. Low phosphorus and medium phosphorus irons, which are mainly used by the general engineering and speciality foundries, are in very short supply, and hematite makers cannot satisfy all demands. Larger tonnages of refined iron are being taken up and many English foundries are glad to avail themselves of the supplies of medium-phosphorus irons which can be spared by Scottish producers.

The position is the reverse in the supply and demand of high-phosphorus irons for the textile, jobbing, and light foundries. Most of the jobbing foundries are busy, but the textile establishments and many of the light foundries need more work. This has resulted in a fall in demand for the high-phosphorus grades of pig-iron, and outputs at present appear to exceed demands; in fact, export merchants have been able to obtain supplies recently for overseas buyers.

The foundries are accepting all available supplies of best heavy and machinery cast-iron scrap, the demand being in excess of supply. Foundry coke is coming forward regularly to satisfy current consumption requirements, and ganister, limestone, and firebricks are in good supply.

Non-ferrous Metals

Unrest at copper mines in Chile and new wage demands on the Copperbelt in Northern Rhodesia are causing some disquiet on the London market. On Monday these events gave a sharp impetus to London Metal Exchange prices with advances of £16 10s. and £15 10s. a ton for three months and cash copper, respectively. In Northern Rhodesia negotiations between the Chamber of Mines and the European Mineworkers' Union have reached a deadlock over the union's claim for a 15 per cent. increase in the basic pay of about 1,300 artisans. The chamber has indicated that the copper-mining companies would be ready to submit the dispute to arbitration if suitable terms of reference could be agreed to by the parties. Meanwhile the African Mineworkers' Union has declared that it is prepared to submit its claim for a general wage increase of 6s. 8d. a shift to arbitration.

In Chile on Monday work stopped at the Chuquicamata, Potrerillos, and El Teniente mines. This action had been threatened as a 24-hour token strike in support of the mineworkers' attitude to resolutions adopted by the Government concerning the labour code, affecting the status of workers in the Chilean copper industry. With the settlement of the strikes the London copper price reacted on Tuesday and values fell away somewhat. It appears that the Chilean Government has rejected the idea of altering its former allocation of copper between Europe and the United States. Chilean copper production this year is estimated at 420,000 metric tons. Although this tonnage and the output for the first half of 1956 has already been sold, it is understood that important offers to purchase copper, particularly from the United Kingdom, have been made, which include two offers to purchase 50,000 tons and 30,000 tons of electrolytic copper, the prices to be fixed at time of delivery.

Dwindling stocks of tin in LME warehouses led to Monday's increase of £6 a ton for cash metal, bringing the price to £780 10s., the highest for 18 months. The firmness of the tone has been further underlined by the entry of the Nigerian tinworkers' strike into the second week. On the other hand, there are indications from Malaya that production in the last quarter of this year may reach a post-war record. In the first nine months output of concentrates reached 45,889 tons, against 45,059 tons in the comparable period a year ago.

Demand for lead continues to be steady on both sides of the Atlantic and talk of an increase in the US price has died down. The belief that any major reduction in capital expenditure schemes in the UK or elsewhere will affect the demand for lead is growing. Demand for zinc is fair and the price is holding. In the US special high-grade metal is in demand, but the call for ordinary brands is steady. US smelters' stocks are unusually low and at their present level of 42,200 tons represents less than two weeks' supply at present consumption levels.

Official metal prices were as follow:—

COPPER, Standard—*Cash:* October 27, £357 to £357 10s.; October 28, £357 10s. to £358; October 31, £370 to £371; November 1, £365 to £367 10s.; November 2, £363 to £364.

Three Months: October 27, £344 to £345; October 28, £345 10s. to £346; October 31, £358 to £359; November 1, £353 to £354; November 2, £350 to £350 10s.

TIN, Standard—*Cash:* October 27, £770 to £771; October 28, £772 to £774; October 31, £780 to £781; November 1, £778 to £780; November 2, £776 to £777.

Three Months: October 27, £754 10s. to £755 10s.; October 28, £755 to £756; October 31, £758 to £759; November 1, £758 to £759; November 2, £756 to £756 10s.

LEAD—*Second half October:* October 27, £106 15s. to £106 17s. 6d.; October 28, £106 7s. 6d. to £106 12s. 6d.; October 31, £106 12s. 6d. to £106 15s. *First half November:* November 1, £106 10s. to £106 15s.; November 2, £106 5s. to £106 10s.

Second half January: October 27, £106 7s. 6d. to £106 12s. 6d.; October 28, £106 to £106 5s.; October 31, £106 10s. to £106 12s. 6d. *First half February:* November 1, £106 5s. to £106 10s.; November 2, £106 to £106 5s.

ZINC—*Second half October:* October 27, £90 15s. to £91; October 28, £90 10s. to £90 15s.; October 31, £90 17s. 6d. to £91. *First half November:* November 1, £90 10s. to £90 15s.; November 2, £90 10s. to £90 15s.

Second half January: October 27, £90 10s. to £90 15s.; October 28, £90 5s. to £90 10s.; October 31, £90 15s. to £90 17s. 6d. *First half February:* November 1, £90 10s. to £90 12s. 6d.; November 2, £90 7s. 6d. to £90 10s.

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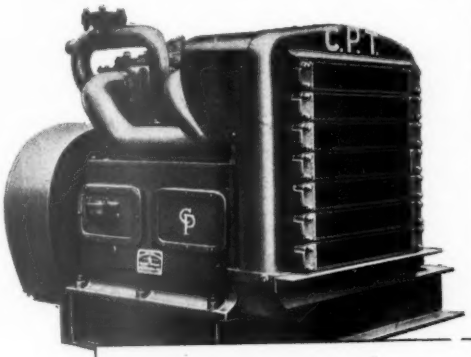


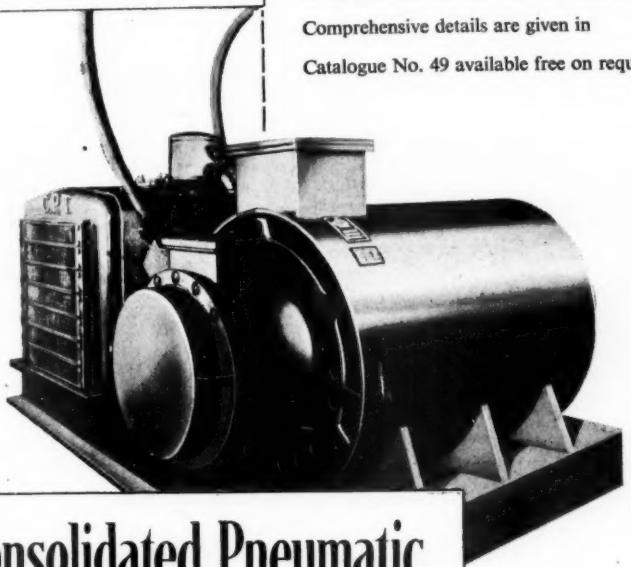
Compactness in design, and air cooling, simplify installation of these Class PB Stationary Compressors.

Wherever a reliable source of air power has to be installed and space is limited, this CP range of two-stage, air-cooled compressors deserves careful consideration.

See how neat they are in design, how compact when built-up on a sub-base, whether belt driven or direct coupled. This means real simplicity in installation.

For compressors that must give more or less continuous service without respite, these reliable units offer an outstanding choice, in capacities of 66, 125, 210, 315 and 500 cu. ft.

Comprehensive details are given in Catalogue No. 49 available free on request.



Consolidated Pneumatic

MAKERS OF HIGH-CLASS ROCK DRILLS, AIR COMPRESSORS AND POWER TOOLS

Current Prices of Iron, Steel, and Non-ferrous Metals

(Delivered unless otherwise stated)

November 2, 1955

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £17 1s. 0d.; Birmingham, £16 13s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £18 12s. 9d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £19 8s. 3d.

Scotch Iron.—No. 3 foundry, £19 5s. 6d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £21 3s. 0d.; South Zone, £21 5s. 0d.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £22 0s. 0d.; South Zone, £22 3s. 0d.

Hematite.—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent. :—N.-E. of England (local iron), £19 5s.; Scotland (Scotch iron), £19 11s. 6d.; Sheffield, £20 12s. 0d.; Birmingham, £20 19s. 6d.; Wales (Welsh iron), £19 11s. 6d.

Basic Pig-iron.—£16 16s. 6d. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered)

Ferro-silicon (6-ton lots and over).—45 per cent. Si, £43 15s. 0d., scale 15s. per unit; 75 per cent. Si, £65 0s. 0d., scale 16s. per unit.

Ferro-vanadium.—50/60 per cent., 23s. 8d. to 25s. 0d. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 11s. 0d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £230 0s. 0d.; 38/40 per cent., £279 0s. 0d.

Ferro-tungsten.—80/85 per cent., 17s. 9d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 20s. 9d. per lb. of W.

Ferro-chrome (6-10 ton lots).—4/6 per cent. C, £85 0s. 0d. to £90 0s. 0d., basis 60 per cent. Cr, scale 25s. 0d. to 30s. 0d. per unit; over 6 per cent. C, £82 0s. 0d. to £86 0s. 0d., basis 60 per cent. Cr, scale 24s. 0d. per unit; 2 per cent. C* 1s. 11¼d. per lb. Cr.; 1 per cent. C,* 2s. 0¼d. per lb. Cr; 0.15 per cent. C,* 2s. 2¼d. per lb. Cr; 0.10 per cent. C,* 2s. 2¾d. per lb. Cr; 0.06 per cent. C,* 2s. 3d. per lb. Cr.

Metallic Chromium.—98/99 per cent., 7s. 0d. to 7s. 6d. per lb.

Metallic Manganese.—93/95 per cent., carbon-free, £249 0s. 0d.; 96/98 per cent., £269 0s. 0d.

Ferro-columbium.—60/75 per cent., Nb + Ta, 28s. per lb., Nb. + Ta.

Ferro-manganese (home).—78 per cent., £54 10s. 0d.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £26 19s. 0d.; tested, 0.08 to 0.25 per cent. C, £27 19s. 0d.; hard (0.41 to 0.60 per cent. C), £29 5s. 6d.; silico-manganese, £36 7s. 6d.; free-cutting, £31 0s. 6d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £34 12s. 0d.; silico-manganese, £36 7s. 6d.

* Average 68-70 per cent.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £31 11s. 0d.; basic, hard, over 0.41 up to 0.60 per cent., C, £32 13s. 6d.; acid, up to 0.25 per cent. C, £35 12s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £33 1s. 6d.; boiler plates (N.-E. Coast), £35 11s. 6d.; floor plates (N.-E. Coast), £34 10s. 6d.; sectional material, N.-E. Coast, £30 19s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £33 19s. 6d.; flats, 5 in. wide and under, £33 19s. 6d.; hoop and strip, £35 1s. 6d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £36 5s. 0d.; black sheets (hand mill), 17/20 g., £46 13s. 6d.; galvanized corrugated sheets, 24 g., £58 11s. 0d.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £58 0s. 3d.; nickel-chrome, £81 10s. 0d.; nickel-chrome-molybdenum, £92 7s. 6d.

NON-FERROUS METALS

Copper.—Cash, £363 0s. 0d. to £364 0s. 0d.; three months, £350 0s. 0d. to £350 10s. 0d.; settlement, £364 0s. 0d.

Copper Tubes, etc.—Solid-drawn tubes, 3s. 6⅝d. per lb.; rods, 414s. 0d. per cwt. basis; 20 s.w.g., 447s. 3d. per cwt.

Tin.—Cash, £776 0s. 0d. to £777 0s. 0d.; three months, £756 0s. 0d. to £756 10s. 0d.; settlement, £777 0s. 0d.

Lead (Refined Pig).—First half November, £106 5s. 0d. to £106 10s. 0d.; first half February, £106 0s. 0d. to £106 5s. 0d.

Zinc.—First half November, £90 10s. 0d. to £90 15s. 0d.; first half February, £90 7s. 6d. to £90 10s. 0d.

Zinc Sheets, etc.—Sheets, 15 g. and thicker, all English destinations, £122 5s. 0d.; rolled zinc (boiler plates), all English destinations, £120 0s. 0d.; zinc oxide (Red Seal), d/d buyers' premises, £103 0s. 0d.

Brass Tubes, etc.—Solid-drawn tubes, 2s. 9⅝d. per lb.; rods, drawn, 3s. 7½d.; sheets to 10 w.g., 355s. 9d. per cwt.; wire, 3s. 4¾d.; rolled metal, 341s. 6d. per cwt.

Brass (Brazing).—BS1400, B3 (65/35), £219; B6 (85/15), —; BS249, £234.

Brass (High Tensile).—BS1400, HTB1 (30 tons), £273; HTB2 (38 tons), £280; HTB3; (48 tons), —.

Gunmetal.—RCH, 3/4 per cent. tin, —; BS1400, LG2 (85/5/5/5), £313; LG3 (86/7/5/2), £322; G1 (88/10/2/⅘), £386; (88/10/2/1), £379.

Phosphor Bronze.—BS1400, PB1 (AID released), £393 per ton.

Phosphor Bronze Strip, etc.—Strip, 501s. 3d. per cwt.; sheets to 10 w.g., 524s. 9d. per cwt.; wire, 5s. 1½d. per lb.; rods, 4s. 5½d.; tubes, 4s. 3¾d.; chill cast bars: solids 4s. 6d., cored 4s. 6½d. (CHARLES CLIFFORD, LIMITED).

Nickel Silver, etc.—Rolled metal, 3 in. to 9 in. wide × 0.056, 4s. 4d. per lb.; round wire, 10g. in coils (10 per cent.), 4s. 8½d.; special quality turning rod, 10 per cent., ½ in. dia., in straight lengths, 4s. 7½d. All prices are net.

Other Metals.—Magnesium, ingots, 2s. 4d. per lb. Antimony, English, 99 per cent., £210 0s. 0d. Quicksilver, ex-warehouse, £91 0s. 0d. to £91 10s. 0d. Nickel, £519 0s. 0d. Aluminium, ingots, £171 0s. 0d.; aluminium bronze, (BS1400), AB1, £363; AB2, —. Solder, brazing, BS1945, 3s. 1d. lb.; granulated, 3s. 4½d. lb.